

Insects as global opportunity

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The growing world population and the rising of economic prosperity are driving the increase of the demand for new nutrients for animal and human nutrition. In particular, proteins are a topic of major concern. Among the conventional protein sources used in animal feed, fishmeal, and soybean meal are probably the ones most accused of being less sustainable. As far as fishmeal is concerned, traditionally produced as fish not considered interesting for human consumption, it is known that since the 1990s, the quantities that can be fished have reached the limit. On the other hand, soybean meal production is associated with high environmental impacts due to deforesting of land, long transportation distances, and the loss of biodiversity. This land could be used to produce aliments for directly human consumption. To face the increasing demand of nutrients for feed and food production, new ingredients and in particular new protein sources are being sought worldwide. These alternative proteins must have a good nutritional value and must be produced sustainable and preferably local.

Insects can be part of the solution and the last decade has seen a growing interest in using insects as a sustainable and nutritious source of raw material for animal feed. Insects contain many nutrients such as proteins, fats, carbohydrates, vitamins, and minerals and are consumed in nature by many animal species. Moreover, edible insects are also consumed humanly. Insects are very capable of converting residual products from the food chain into high-quality nutrients and this stimulates circularity, which is extremely important in these times with a scarcity of raw materials. Worldwide, we see that there is increasing attention for rearing insects as a source of nutrients, how these insects should be reared and fed, how the insects can be processed into an ingredient, how to use them in human food and animal feed, how the safety of these insects can be guaranteed in the food chain and how sustainable it is to include insects as an important link in the food chain.

The main aim of the current issue of *Animal Frontiers* is to provide an overview of the development of insects in the

global food chain. This special issue tackles different important aspects of the application of insects and their nutrients in animal feed.

In the context of legislation, strong collaborations between industrial associations, research and academic organizations are required for biowaste materials and bioconversion of these materials.

Reviewing the current state of insect protein research and production for feed and food markets in Australia, [Digiacomio \(2023\)](#) highlights that the industry is in the start-up stages but has great potential to develop as a world leading diverse, sustainable, inclusive, and profitable industry that assists in dealing with challenges from other agricultural sectors including waste management and resource availability. In order to develop, the sector needs the support of a clear legislation capable of guaranteeing product safety. Moreover, investments in research and development, infrastructures, education and marketing are also needed.

The edible insect markets in Canada and the United States are rapidly expanding, but insect production volumes are still insufficient to meet demand, as demonstrated by the paper by [Larouche et al. \(2023\)](#).

[Tanga and Kababu \(2023\)](#) provide new insights into Africa's emerging edible insect industry. In their review, they demonstrate that insect farming is a growing agribusiness, highlighting the status and emerging gaps in edible insect farming, the role of private sectors, potential estimates, processing, nutritional composition, safety, application, and the legislative framework governing the industry. Although the industry is still in its infancy, the authors conclude that this environmentally friendly insect-based technology is already benefiting vulnerable groups in Africa such as youth, women, and the displaced.

[Deguerry et al. \(2023\)](#) report the growing role of insects in the Asian (India, Indonesia, Malaysia, Singapore, and Thailand) feed industry. They describe the huge potential of the insect sector, underlying how the heterogeneity of the regulatory context of these very diverse countries can present huge opportunities but can also generate multiple challenges for stakeholders for the production and commercialization of insect-based products. In these countries, the black soldier fly (*Hermetia illucens*) is the predominant reared species. The high price of the insect-derived products remains an obstacle to the full development of the sector. The authors indicate the improvement of processes

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with a consequent increase in production, the enlargement of the substrates allowed for insect breeding, the demonstration of the beneficial functional properties of the insect' bioactive compounds among the principal factors that will make it possible to overcome the current critical issues.

In addition to overviews of major issues in various regions of the world, this special issue focuses on various aspects of the application of insects and their nutrients.

Considering the importance of insects as protein suppliers, [Malla et al. \(2023\)](#) reviewed the advantages and limitations of the existing methodologies to evaluate protein digestibility and quality for food and feed application. Moreover, the paper provides a concise review of the available information on insect protein quality.

[Tomberlin et al. \(2023\)](#) reviewed the impact of essential amino acids on insect biology and described how substrate for growing insects can be tailored to avoid essential amino acid deficiencies and allow for optimal waste-to-insect biomass conversion.

[Biasato et al. \(2023\)](#) reviewed the current state of knowledge on the microbiota (and microbiome, when available) of monogastric animal species such as poultry, fish, pigs, and rabbits fed insect-based products (meals, fats, and live larvae). The authors identified the main ways of action of insects in the animal gut and a different species-specific response, also concluding that omics technologies appear to be critical for investigating the functional significance of observed microbiota changes.

[Gasco et al. \(2023\)](#) discuss the interest in using insects in the circular economy, the manufacturing process, the nutritional and health properties of insect meals, and the main performance results obtained with aquaculture and monogastric livestock species fed insect meals. Large quantities of insect meals with consistent quality and chemical composition are required for use in feed. Insect meals have nutritional value comparable to or greater than conventional protein sources in animal feed, and they may even improve animal health and welfare. Authors also briefly reviewed the interest of insect frass within the circular economy value chain.

[Barragán-Fonseca \(2023\)](#) demonstrates how insect meal from the black soldier fly (*Hermetia illucens*) can be used in feed on small-holder tilapia (*Oreochromis niloticus*) farms in the Global South. The author focus not only on animal production but also on how the use of BSF insect meal can help with income generation and the circular economy.

[Renna et al. \(2023\)](#) discuss the legislation, scientific evidence, and future challenges of using insects as ruminant feed. Insects are promising alternatives to traditional protein and fat sources for ruminants, but legislation for protein-rich insect meals is more stringent than for insect oils. In this review, the authors show how insect products, in addition to provide nutrients, may modulate the rumen environment, e.g. CH₄ emissions and lipid biohydrogenation. These findings could be of enormous importance for mitigating the environmental impact of the livestock sector. As safety remains a priority, research is needed to deliver data to confirm or reject a role of insects as vectors of prions.

The special issue concludes with a paper of [Smetana et al. \(2023\)](#) in which the environmental impact potential of insect production chains for food and feed in Europe is presented. Authors underlined how the results are impacted by the insect species, the type of feed used as insect rearing substrate and the production method. Moreover, to fully evaluate the insect production potential as a sustainable system, it is necessary to consider several sustainable indicators, among which economic, social and environmental aspects.

About the Author



Laura Gasco is a Full Professor at the Department of Agricultural, Forest and Food Sciences of the University of Turin (Italy). Laura focuses her research on fish, rabbit and poultry farming and nutrition assessing performances and the impact of alternative ingredients on product quality. Since 2012 her research is focused on the use of insect meals as innovative ingredients in animal nutrition and on the optimisation of insect rearing for the production of high quality raw materials. In particular, her research focuses on the black soldier fly (*Hermetia illucens*) and on the yellow mealworm (*Tenebrio molitor*). She

is involved in projects related to insects as feed. Laura is president of the Study Commission Insects of the European Federation of Animal Science and a member of the editorial board of the Journal of Insects as Food and Feed.

TEUN VELDKAMP is a senior researcher animal nutrition / insects as feed in the Animal Nutrition department of Wageningen Livestock Research. Dr. Veldkamp joined Wageningen Livestock Research in 1989. In 2002 he obtained his Ph.D. on the thesis "Heat stress and diet utilization in male turkeys – The role of dietary energy and amino acids". Now he is working on poultry nutrition research in broilers, laying hens and turkeys. The main research topics in poultry nutrition are feed evaluation, amino acid requirements, feed additives: efficacy and tolerance trials for registration purposes and since 2012 Dr. Veldkamp is involved in many projects related to insects as feed, food and non-food. In these projects, he is focusing on biowaste conversion by use of insects, insect rearing, and application of insect-derived products in animal nutrition. Dr. Veldkamp is the coordinator of the H2020 project SUSINCHAIN (Sustainable Insect Chain) and is the former president of the Study Commission Insects of the European Federation of Animal Science (2016-2022). Furthermore, he is a member of the editorial board of the Journal of Insects as Food and Feed.



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