SUSINCHAIN
SUSTAINABLE INSECT CHAIN

PRESS RELEASE

SUSINCHAIN Unveils Best Practices to Propel Insect Protein Supply Chain for Feed and Food in Europe

SUSINCHAIN, an innovative project committed to advancing sustainable and efficient protein provision for feed and food in Europe, is thrilled to announce the release of its groundbreaking Best Practices sheets. Now available on the project's website, these invaluable resources aim to overcome the remaining barriers and enhance the economic viability of the insect value chain.

In the pursuit of sustainable protein solutions, SUSINCHAIN has embarked on a mission to revolutionize the way we produce and utilize insect protein for feed and food. With an emphasis on testing, piloting, and demonstrating cutting-edge technologies, products, and processes, the project aims to achieve a high Technology Readiness Level (TRL). Moreover, SUSINCHAIN actively engages with stakeholders through living labs and workshops to foster collaboration and knowledge sharing within the insect protein supply chain.

The newly unveiled Best Practices sheets represent a culmination of extensive research, hands-on experimentation, and collaboration with industry experts. By offering actionable insights and guidelines, these resources are poised to transform the insect protein value chain and unlock its immense potential.

Key highlights of the SUSINCHAIN Best Practices sheets include:

- Technological Advancements: Explore the latest technologies, innovations, and advancements in insect rearing, processing, and refining techniques to maximize efficiency and scalability.
- Quality Assurance and Safety Standards: Gain an understanding of the stringent quality assurance measures and safety protocols necessary for the production and distribution of insect protein for feed and food.
- Regulatory Compliance: Navigate the complex regulatory landscape surrounding insect protein, ensuring compliance with relevant regulations, standards, and certifications.
- Circular Economy Integration: Discover strategies to embrace the circular economy principles by optimizing resource efficiency, reducing waste, and exploring novel approaches for the valorization of by-products.
- Stakeholder Collaboration: Learn how to engage with stakeholders throughout the insect protein value chain, foster knowledge exchange, and establish collaborative networks to drive innovation and address shared challenges.

SUSINCHAIN's Best Practices sheets provide an invaluable resource for businesses, researchers, and policymakers aiming to capitalize on the economic and environmental benefits of insect protein production. By implementing these best practices, the European feed and food industry can drive sustainable growth, reduce reliance on traditional protein sources, and contribute to a more resilient and resource-efficient food system.

The SUSINCHAIN Best Practices sheets are now available for download on the project's website at https://susinchain.eu/project-outcomes/best-practice-sheets/. Interested parties are encouraged to access these resources and join the journey towards a more sustainable protein future.

SUSINCHAIN project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 861976.

About SUSINCHAIN:

SUSINCHAIN is a pioneering project focused on propelling the insect protein value chain for feed and food in Europe. By leveraging advanced technologies, stakeholder collaboration, and innovation, SUSINCHAIN aims to overcome barriers and increase the economic viability of insect protein production. The project actively promotes sustainability and resilience in the feed and food industry, contributing to a more efficient and sustainable protein provision.

SUSINCHAIN received funding from the European Union's H2020 programme under the grant agreement 861976. This project has been funded with support from the European Commission.

For future updates on the project and announcements follow the SUSINCHAIN website.

SUSINCHAIN Scientific Publications

Potential of Fermentation and Vacuum Packaging Followed by Chilling to Preserve Black Soldier Fly Larvae (Hermetia illucens)

The article **"Potential of Fermentation and Vacuum Packaging Followed by Chilling to Preserve Black Soldier Fly Larvae (Hermetia illucens)"** was published by **Leen Van Campenhout, Dario Lachi, and Dries Vandeweyer in** *Insects 2021, 12(8), 714* in 2021. This article belongs to the Special Issue of the magazine, Sustainable Insect Chains.

Simple Summary: Insects are being produced at an industrial scale, mainly as feed ingredient to replace less sustainable protein sources in feed. Larvae of the black soldier fly (Hermetia illucens) are currently the most important species reared for this purpose. After production, it is necessary that the larvae be stored and transported in a stable way, i.e., without deterioration. In this study, we investigated fermentation and vacuum packaging technology as potential stabilisation techniques. Fermentation appears to be possible when the larvae are first blanched and pulverised, but bacterial endospores remain present and can potentially be dangerous if the conditions are not acidic enough. Vacuum packaging was tested as storage technique for living larvae, but their survival was lower than for living larvae packaged in air. Additionally, for killed larvae, vacuum packaging before chilling did not bring benefits over chilled storage alone. That was concluded from the fact that microbial counts were similar for larvae that were packaged in air or under vacuum during storage. Abstract: Black soldier fly larvae (Hermetia illucens) are currently reared at an industrial scale, mainly as a feed ingredient. The logistic chain not only involves the production of larvae, but also stabilisation, storage, and transport. The aim of this work was to study fermentation and vacuum packaging of larvae as potential preservation technologies. For fermentation, blanched larvae were pulverised into a paste, and a starter culture, NaCl, and glucose were added. The mixture was fermented for 7 days at 35 ◦C and then stored for 14 days at 4 ◦C and pH and microbial counts were monitored. Vacuum packaging was applied to living, blanched and frozen larvae. After packaging, they were stored for 6–10 days at several temperatures and gas composition, survival (living larvae) and microbial counts (killed larvae) were recorded. Fermentation allows storage of pulverised larvae, but points to consider are a rapid pH reduction and the presence of bacterial endospores. Vacuum packaging did not bring added value over cooling alone. This was the case for all types of larvae investigated. Vacuum packaging is not considered as a valuable preservation technology to pursue for storage and transport of black soldier fly larvae.

To the authors' knowledge, vacuum packaging has not yet been investigated as a preservation technology for insects, and our results cannot be compared to findings of others. Based on our data, the technology does not seem to be able to replace cooling or to bring an additional advantage on top of cooling. This is the case for both living and killed larvae, either by blanching or freezing. Further research is necessary to find the most optimal (in terms of obtained shelf life in

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combination with capital and operational expenditures) technologies for BSFL and other insects. In the case of killed insects, our study demonstrated that the killing method can affect the microbiological condition at the start of the storage period. Likely also the chemical composition may be impacted. Hence, when designing storage methods, the killing technique should be taken into account. MAP encompasses vacuum packaging, but also packaging in altered gas compositions. As experienced in other research (data not yet published), killed BSFL are prone to oxidation, even when kept frozen. Packaging in 100% N2 may prevent or limit oxidation processes, but it remains to be investigated in future research

The article can be accessed online at the journal website or the SUSINCHAIN project website along with other scientific publications.

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SUSINCHAIN Scientific Publications

Environmental aspects of insect mass production

The article **"Environmental aspects of insect mass production"** was published in the the *Journal of Insects as Food and Feed, Vol. 7, No. 5, 2021, Special Issue: Advancement of insects as food and feed in a circular economy* (pages: 553 – 571) by the Wageningen Academic Publishers by **S. Smetana, R. Spykman, V. Heinz.**

Abstract Mass production of insects is calling for environmentally optimised and economically efficient insect value chains. It is a complex task considering a great variety in insect species, production scales, feed formulations, etc. Taking a challenge of environmental impact clarification, a few studies highlight on life cycle assessment (LCA) of insect production. The current study is aimed to systemise 24 selected previous studies to establish a modular framework for the determination of contribution of sustainability assessment factors of insect production chains. Reviewing published studies according to the elements of LCA, the study identified a feasible approach for the modelling of insect production chains, which can be used for the facilitation of comparability of further LCA studies. The approach is based on a modular analysis of insect production through a graphical mapping of value chains (allowed identification of precise system boundaries) supplemented with table analysis considering scale of production, reference (functional) unit, impact assessment methodology and type of LCA. Such an approach allows for consistency in LCA setting and further comparability of results.

Conclusions The study was oriented to review current scientific literature to establish a modular framework for the determination of environmental contribution of different parts of insect production chains. Most LCA studies concentrated on attributional approach with results presented for several impact categories. Analysed studies relied on diverse impact assessment methods (LCIA) which can be grouped into ReCiPe, IMPACT 2002+, CML, ILCD and separate indicators. The goal of reviewed LCA articles deals with estimation of environmental impact of insect production for food and feed purposes to waste and manure treatment scenarios. Most studies rely on primary data from pilot insect production or on mix of primary data and information from https://www.wageningenacademic.com/doi/pdf/10.3920/JIFF2020.0116 - Thursday, September 30, 2021 9:54:16 AM - IP Address:79.168.1.153 S. Smetana et al. 568 Journal of Insects as Food and Feed 7(5) the literature. There is a lack of studies, which would include the transportation and distribution of insect biomass/ products, as most studies concentrate on cradle-to-gate approach. The studies also reflected on environmental hot spots, which included production of feed (in case of commercial feed), insect cultivation and processing. Most impacts are associated with use of energy (electricity, fuel, natural gas). These factors are associated with high impacts in categories of global warming potential, non-renewable energy use, water and land use. Type of feed and modelling of its assessment was in many cases decisive for the determination of the environmental impact of insects. The selection of by-product allocation rules, substitution criteria, and waste scenarios determined the wide ranges of environmental impacts presented for food processing by-products, food waste and manure. Most LCA studies concentrated production of three insect species: Hermetia illucens, Tenebrio molitor and Musca domestica. Other five species are covered by single studies. The analysis indicated that research literature is very diverse in the

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scope and boundaries of the LCA, selection of FU, LCIA methodologies, assessed insect species, scale of production and other aspects. For performing further LCA studies a systemised modular approach was suggested. It consists of three stages: (1) determination of system boundaries of insect production chains and relevant comparable studies via graphical mapping; (2) the modularisation of insect production chain according to the modularisation scheme and LCIA approaches; (3) the consideration of a FU and production scale which may affect the results and alter the final outcomes and conclusions

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PRESS RELEASE

SUSINCHAIN Scientific Publications

Introduction to the EU H2020 project SUSINCHAIN (SUStainable INsect CHAIN)

The article "**Insects to Feed the World 2020 Virtual Conference"** is a supplement of the *Journal of Insects as Food and Feed* and was published in 2020 at *Journal of Insects as Food and Feed: 6 (Supplement 1)- Pages: S1 - S88*.

The Editor-in-chief of the supplement was **Prof. Arnold van Huis (Wageningen University).**

The article can be accessed online at the journal website or the SUSINCHAIN project website along with other scientific publications.

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SUSINCHAIN Scientific Publications

Dynamics of Salmonella inoculated during rearing of black soldier fly larvae (Hermetia illucens) on chicken feed

The article **"Dynamics of Salmonella inoculated during rearing of black soldier fly larvae (Hermetia illucens) on chicken feed"** was published **by J. De Smet, D. Vandeweyer, L. Van Moll, D. Lachi, L. Van Campenhout in** *Food Research International, Vol.149* in November 2021.

Highlights

- BSFL does not show a reducing effect on *Salmonella* counts on chicken feed.
- The background microbiota is an important factor during inoculation experiments.
- Airborne transmission is possible in laboratory conditions during insect rearing.

Salmonella free substrate is recommended to avoid the pathogen entry in rearing

he black soldier fly is currently the most produced edible insect on industrial scale, with its larval stage being processed into animal feed as the main application. As this insect species enters the feed and food chain, good hygiene and monitoring practices are needed to avoid the entrance of foodborne pathogens via the larvae. However, insufficient data on the risk of such introductions via industrial larvae production are available. To address this gap, a range of rearing trials were conducted in which the substrate, chicken feed, was inoculated with different levels of *Salmonella* and in which total viable counts and *Salmonella* counts were determined during the following days. The outgrowth of *Salmonella* was slower in those experiments with a lower initial contamination level than in experiments with a higher level. No significant reducing effect originating from the larvae on the substrate *Salmonella* counts was observed, in contrast to previous studies using other substrates. Our study also revealed that airborne transmission of *Salmonella* is possible under rearing conditions corresponding to those applied at industrial production sites. Based on our results, we recommend insect producers to use substrate ingredients free of *Salmonella*, and not to count on the antimicrobial activities that BSFL may exert in some situations towards food pathogens. More inoculation studies using other *Salmonella* serotypes, other zoonotic bacteria, other substrates, larvae of other ages and including variations on rearing protocols are needed in order to obtain a general view on the dynamics of food pathogens in this insect species and to support comprehensive risk assessments.

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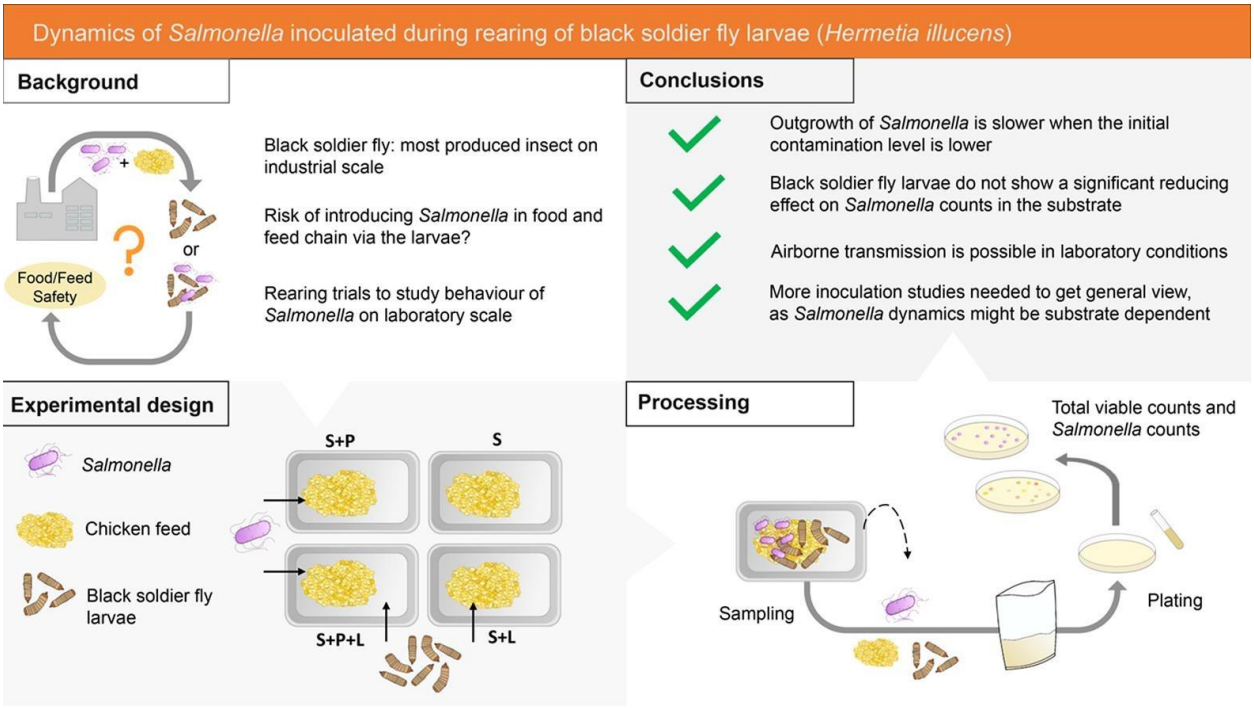

Our study revealed that, when reared on chicken feed, BSFL does not show a reducing effect 453 on Salmonella counts in the substrate. It can be concluded though, that outgrowth of Salmonella available under aCC-BY-NC-ND 4.0 International license. was not certified by peer review) is the author/funder, who has granted bioRxiv a license to display the preprint in perpetuity. It is made bioRxiv preprint doi: https://doi.org/10.1101/2021.04.13.439665; this version posted April 13, 2021. The copyright holder for this preprint (which 16 454 is slower when the initial contamination level is lower. In addition, our study demonstrates that 455 airborne transmission is possible in laboratory conditions and we expect that it also may occur 456 in industrial production facilities. Altogether, these observations lead to the general 457 recommendation for insect producers to use substrate ingredients free of Salmonella, to avoid 458 the entrance of the pathogen in the rearing and post-harvest processing line by any other route, 459 and not to count on the antimicrobial activities that BSFL exert in some situations to eradicate 460 the food safety risk. Future inoculation experiments are needed, using other Salmonella 461 serotypes and other zoonotic bacteria, other substrates, larvae of other ages and variations on 462 the rearing protocols to further elaborate on the dynamics of this pathogen and to support risk 463 assessments. From our study, we can advise on the use of antibiotic resistant organisms to allow 464 a proper monitoring of the inoculated strain. PCR technology can also assist in pathogen 465 monitoring, provided proper primers for the target organism are available and background 466 interference of the matrix can be excluded.

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SUSINCHAIN Scientific Publications

Nutritional qualities and enhancement of edible insects

The review article **"Nutritional qualities and enhancement of edible insects"** was published in *Annual Review of Nutrition, Vol. 41:551-576 (October 2021)* by **Arnold van Huis, Birgit Rumpold, Cassandra Maya, Nanna Ross** in 2021. It first published as a Review in Advance on June 29, 2021.

Over the last decade, the urgency to find alternative and sustainable protein sources has prompted an exponential increase in the interest in insects as a human food source. Edible insects contribute suitable amounts of energy and protein, fatty acids, and micronutrients to the human diet. Nutritional values of insects can be manipulated to meet specific needs. Edible insects in food-insecure countries can contribute to improving diets and preventing undernutrition. Bioactive compounds in insects may reduce health risks. Food safety risks are low and mainly relate to those of allergenicity. Strategies to overcome barriers to the consumption of insect products include emphasizing their sustainability, increasing their tastiness, and developing the ability to disguise insects in familiar products. A new sector of insects as food and feed is emerging. Major challenges include legislation, lowering prices by automation and cheap substrates, developing insect products that appeal to consumers, and exploring the health benefits.

Edible insects have been a part of traditional diets in food cultures across the world. So why have insects as a potential food source been ignored for such a long time in the Western world? One practical reason is that there is much more opportunity to use them as food in tropical countries, due to the prevalence of larger insects with a clustered occurrence and year-round availability. Eating behavior and preferences are strongly influenced by upbringing, past experiences, and cultural traditions. The psychological factor of acceptance of foods is strong in any culture. In Western cultures, insects are strongly associated with diseases (as vectors), dirt and filth (cockroaches), and annoyance (houseflies). Also, in food cultures that traditionally include edible insects, the focus should be on introducing specific insect species and not a universal perception of insects being edible. The circular economy being pursued by many governments is considered an opportunity, as food products from insects can be produced more sustainably than those from the conventional livestock industry. Therefore, in the past decade, there has been an exponential increase in the interest shown in edible insects by academics and private enterprise. Insects are now recognized as an overlooked resource of novel production systems to supply more sustainable animal-derived foods. The global climate and environmental crises require transitions of food systems, and the farming of insects can be a significant contributor in this respect. Edible insects are a potential tool for transforming organic waste into high-value proteins and food ingredients. For insects to be considered as a meat replacement and alternative protein source, they must compete with meat as well as with plant proteins in price and nutritive value. Insect products for human consumption are generally too expensive for the retail market. Low market demand does

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not allow economies of scale. The price can be lowered by automating rearing processes and identifying and testing cheap organic side streams as feed substrate. Those streams should be available in reliable large quantities of constant quality and not pose any health risks. There is probably a trade-off between the cheapness of the product and the performance (survival and development) of the insect. Higher prices for insect-based products than for those of conventional foods may be justified if they are proven to be more sustainable and when health claims can be substantiated. The nutrient and chemical content of insects greatly depends on the feed substrate. This is both an opportunity and a challenge to tailor insect nutrient profiles for groups with specific dietary needs. The uptake of these targeted nutrients from the insects' diet needs to be optimized and justify the detour via insects from both a nutritional and an economic point of view. Novel industries require investments for the development or adaptation of techniques for rearing, processing, and conservation. However, the problem is that innovations are often kept secret or are protected by patents, often by a few large-scale companies. The growing investments in research and innovation in edible insects are now emerging; however, only a fraction of the past and continued research investment is presently established in food production systems. On the question of processing, either whole insects or specific insect components, such as emulsifiers, gelling agents, or thickeners, can be used (93). Processing insects into safe and appealing food products meeting consumer demands continues to be challenging. Existing processing www.annualreviews.org • Nutritional Qualities of Edible Insects 567 Annu. Rev. Nutr. 2021.41:551-576. Downloaded from www.annualreviews.org Access provided by 79.168.1.153 on 12/21/21. For personal use only. techniques from the food industry are available but must be tailored and optimized for the insect industry. More data are needed to assess the effect of insect processing techniques on the nutritional content. The consistency in the quality of edible insects needs to be improved. Another question is how high the percentage of insect ingredients in a food item should be before it can be called an insect-based food. Edible insects are highly complex organisms and constitute a pool of potential bioactive compounds that can support human health and supply nutrients. Because the current evidence supports the existence of bioactivity of interest, further investigations should be conducted. Additionally, the current knowledge primarily relies on in vitro studies; therefore, human studies are required to find out whether the observations have significant health impacts. Taste is the main driver of consumer acceptance. To reach consumers,insect-based foods should look and taste good. The current phase of innovation and market introduction covers a wide range of products with variable qualities. A more mature market for insects will help consumers to select high-quality products and allow the industry to continue to develop more attractive products. Research should continue to provide evidence for the potential health and environmental benefits of insects, which will also support the consumers in their choice. The sustainability, health, safety, and price of processed insects may be important incentives for consumers looking for alternatives to traditionally produced animal proteins (53). How can consumers be persuaded to consume insects as a snack or a meat substitute? The psychological factors related to disgust and cultural inappropriateness should be further investigated (109, 126), as people may adapt to disgust (125). To create market demand, the involvement of chefs, restaurateurs, the catering industry, role models, and policy makers is required. Notably, deliciousness is a prerequisite for any progress in the industry. Consumers should also be made

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aware of the potential health and environmental benefits. Food insects have a tremendous potential for improving food security. They are highly nutritious and can be sustainably produced in a circular economy. Their nutrient profile can be modified and enriched for specific purposes. Moreover, bioactive compounds present in food insects can have advantageous health benefits. Because insect products have been on the market for less than a decade, legal frameworks are absent or still being conceived. The safety of insect-based products needs full attention, as food safety is closely linked to legislative approval. Safety also relates to substrates as well as to microbial risks related to processing, storing, packaging, and transport. Other challenges are economic production on an industrial scale, allergenic potential, and lack of Western consumer acceptance. Although there are still numerous research questions to be tackled, the insect industry is becoming a promising new sector in food and agriculture.

The article can be accessed online at the journal website or the SUSINCHAIN project website along with other scientific publications.

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SUSINCHAIN Scientific Publications

Effect of Probiotics on Tenebrio molitor Larval Development and Resistance against the Fungal Pathogen Metarhizium brunneum

The article **"Effect of Probiotics on Tenebrio molitor Larval Development and Resistance against the Fungal Pathogen *Metarhizium brunneum*"** was published in *Insects 2022, 13(12), 1114* by **Sabina Dahal, Annette Bruun Jensen, Antoine Lecocq** in 2022.

Simple Summary: Insects have been widely studied as a potential sustainable source of proteins to meet a rising global demand. Among them, the yellow mealworm (Tenebrio molitor, L.) is showing promise for its mass-rearing potential and its authorization by the European Union (EU) as a novel food. As in conventional animal husbandry practices, probiotics could provide nutritional and immunological benefits as part of the insect's diet. This study evaluated the dietary supplementation of three types of probiotics on the development and disease resistance of yellow mealworm larvae. The results showed that the addition of probiotics can play a role in insect farming to improve the nutritional value of sub-optimal diets and protect the insects against entomopathogens. However, this study emphasizes the contrasting effects of the different probiotic strains tested and the need for more research on the topic. Abstract: In recent years, the yellow mealworm (Tenebrio molitor L.) has demonstrated its potential as a mass-produced edible insect for food and feed. However, challenges brought on by pathogens in intensive production systems are unavoidable and require the development of new solutions. One potential solution is the supplementation of probiotics in the insect's diet to obtain the double benefits of improved growth and enhanced immune response. The aim of this study was to evaluate the effects of diet-based probiotic supplementation on T. molitor larval survival, growth, and resistance against a fungal pathogen. Three probiotic strains, namely Pediococcus pentosacceus KVL-B19-01 isolated from T. molitor and two commercialized strains for traditional livestock, Enterococcus faecium 669 and Bacillus subtilis 597, were tested. Additionally, when larvae were 9 weeks old, a pathogen challenge experiment was conducted with the fungus Metarhizium brunneum. Results showed that both P. pentosaceus and E. faecium improved larval growth and larval survival following fungal exposure compared to the non-supplemented control diet. Since B. subtilis did not improve larval performance in terms of either development or protection against M. brunneum, this study suggests the need for further research and evaluation of probiotic strains and their modes of action when considered as a supplement in T. molitor's diet.

This study demonstrated the developmental and health benefits of dietary supplementation with probiotic strains P. pentosaceus and E. faecium in T. molitor larvae. These two strains improved larval growth and larval resistance against the entomopathogenic fungus M. brunneum. However, the B. subtilis strain used in this study was shown to have the opposite effect on T. molitor, resulting in decreased larval growth and increased susceptibility to M. brunneum. The exact mechanism

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behind the probiotic effects still needs to be revealed in future studies. In addition to this, the suitability of probiotic strains for diet supplementation also requires further study.

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SUSINCHAIN Scientific Publications

The influence of wet feed distribution on the density, growth rate and growth variability of Tenebrio molitor

The research article **"The influence of wet feed distribution on the density, growth rate and growth variability of Tenebrio molitor"** was published in *Journal of Insects as Food and Feed, 2021; 7(2) (pages 141-149)* by **D. Deruytter, C.L. Coudron, J. Claeys.**

Mealworm larvae have the potential to be a future food and feed. One of the difficulties in rearing mealworms efficiently, is their need for both dry and wet feed. Extensive research has been done on dry feed and distributing this feed is easy with the existing technology. However, the wet feed (frequently chopped up vegetables) comes with several challenges. The nature of the wet feed (neither solid nor liquid) complicates automation, making manual feeding still the norm in many farms. This may result in an unequal distribution of the wet feed.

The entire larval growth stage was assessed from less than 1 mg up to more than 100 mg, as differences in mobility were expected for different sized larvae. The results indicate that the distribution of the agar plays a major role in the distribution and growth of the larvae, with less larvae and a decrease in growth rate observed when the agar was more than 5 to 10 cm away from the larvae. Few mealworms were found more than 15 cm from the agar, and their growth was inhibited resulting in a biomass up to 150 times lower than near the agar. The effects were mainly observed in larvae weighing less than 30 mg, heavier mealworms were mobile enough to crawl to and from the agar. Based on the results, and in order to ensure that all larvae sizes grow equally well and are well distributed in the crate, we strongly advise against distances of 10 cm or more and we recommend the placement of wet feed within 5 cm from the larvae.

The research article aimed to assess the influence of the distribution of wet feed (substituted by agar) on the density, growth rate, and growth rate variability of mealworm larvae. The researchers developed an understanding how the distance to the wet feed affected the distribution and growth of the larvae, particularly in relation to their size. Another goal for the study was to determine the optimal placement of wet feed to ensure equal growth and distribution of larvae in a crate, considering the challenges associated with automating the distribution of wet feed in mealworm rearing.

The research provided in the article, focuses on the distribution of wet feed (substituted by agar) and its impact on the density and growth of mealworm larvae. While extensive research has been conducted on dry feed, the challenges associated with distributing wet feed hinder automation, leading to manual feeding in many farms. The findings indicated that larvae dispersal and growth are greatly influenced by the availability of agar, which is employed as wet feed. Less larvae are found and their growth rate slows down when the agar is more than 5 to 10 cm away from the larvae. Larvae located more than 15 cm from the agar exhibit inhibited growth, resulting in

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significantly lower biomass compared to those near the agar. These effects are primarily observed in larvae weighing less than 30 mg, as heavier larvae are more mobile and can reach the agar. In order to achieve even growth and dispersion of all larval sizes, the study suggests placing the wet meal within 5 cm of the larvae.

The research provided underlines the significance of moist feed distribution in an industrial setting as well as during tests. The effectiveness of mealworm farming is increased by distributing wet feed uniformly, which enhances growth and density distribution.

The study more investigation is required to establish the ideal larval density and behavior in the presence of several wet nutrition sources. Overall, the study advises against keeping larvae of all sizes more than 10 cm away from a feed source and emphasizes the potential advantages of evenly distributed wet feed in mealworm development.

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PRESS RELEASE

SUSINCHAIN Scientific Publications

Profitability of insect farms

The review article **"Profitability of insect farms"** was published in 2021 in the *Journal of Insects as Food and Feed, Vol. 7, No. 5, 2021, Special Issue: Advancement of insects as food and feed in a circular economy* (pages: 923 – 934) by *the Wageningen Academic Publishers* **by Niyonsaba, H. H., Höhler, J., Kooistra, J., Van der Fels-Klerx, H. J., & Meuwissen, M. P. M.**

Among the points of the article were to demonstrate the current data on the profitability of insect production (such as Hermetia illucens, Alphitobius diaperinus, Tenebrio molitor and Acheta domesticus) as well as to make an overview of the economic figures underlying its profitability.

The review made addresses the scarcity of knowledge regarding the profitability of commercial-scale insect production. The authors aimed to provide insights into the economic figures and profitability of producing specific insect species. There were analyzed the operational costs and sales prices of Hermetia illucens, Alphitobius diaperinus, Tenebrio molitor, and Acheta domesticus.

The results of the study emphasize the need for accurate data on profitability for farmers, banks, and governments and support the growth of the insect production sector.. Yet it is mentioned that the limited availability of reliable sources and the heterogeneity of research methods pose challenges in interpreting the economic figures. The authors presented ranges for each insect species but caution against direct comparisons due to variations in cost components and processing formats. They highlight the importance of considering capital expenditures, financing costs, and quality factors in assessing profitability.

This review article addresses the lack of information on the profitability of insect farming and provides economic figures for specific insect species. The authors highlight the challenges in obtaining reliable data and emphasize the need for further research. The review concludes that additional research is required in order to improve understanding and provide accurate economic data for the insect production sector-

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PRESS RELEASE

SUSINCHAIN Scientific Publications

A modular environmental and economic assessment applied to the production of Hermetia illucens larvae as a protein source for food and feed

The article **"A modular environmental and economic assessment applied to the production of Hermetia illucens larvae as a protein source for food and feed"** was published in ***The International Journal of Life Cycle Assessment (2021) 26: 1959–1976 (2021)*** **by Raphaela Spykman, Sayed Mahdi Hossaini, Daniela A. Peguero, Ashley Green, Volker Heinz & Sergiy Smetana** in 2021.

The study presented in the article aimed to give a analysis of environmental and economic impacts of insect production to identify the most eco-efficient production scenarios.
The authors of the article highlight on the significant role of the insect protein as a promising solution to ensure future food security and mitigate negative environmental impacts related to food production. It is also noted that producers need a decision-support system to ensure the sustainable upscaling of the sector.
What makes research important is a novel modular eco-efficiency assessment approach developed to analyze the production of dried Hermetia illucens larvae. Authors disaggregated an exemplary, industrial-scale insect production system into a total of 29 module variants that can be combined into 4608 distinct production scenarios, which are characterized by different feeds, energy efficiencies, and processing technologies. Environmental life cycle and cost assessments were conducted for each module variant, while eco-efficiency assessment was utilized to evaluate sustainability in terms of both environmental and economic dimensions. Furthermore, the impact of insect feed on production system performance and environmental footprint was examined by employing feed-specific scaling factors. These factors were employed to aggregate module results into production scenario outcomes.
The results of the studies showed that the most environmentally and economically efficient production scenarios were characterized by energy-efficient rearing facilities that utilized blanching and microwave drying for processing. The choice of insect feed was found to be the primary contributor to both environmental impacts and costs. However, from an eco-efficiency perspective, the specific feed option may not be critical.
The researchers came to the conclusions that the developed method of determining eco-efficiency based on cost-analysis and modular life cycle assessment tested in the study demonstrated to be efficient in assessing multiple potential insect production scenarios.

The article can be accessed online at the journal website or the SUSINCHAIN project website along with other scientific publications.

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PRESS RELEASE

SUSINCHAIN Scientific Publications

A Review of Pretreatment Methods to Improve Agri-Food Waste Bioconversion by Black Soldier Fly Larvae

The article **"A Review of Pretreatment Methods to Improve Agri-Food Waste Bioconversion by Black Soldier Fly Larvae" by** Daniela A. Peguero, Moritz Gold, Dries Vandeweyer, Christian Zurbrügg, and Alexander Mathys This article was submitted to Waste Management in Agroecosystems, a section of the journal Frontiers in Sustainable Food Systems in 2022.

The review presented in the article meets the request for solutions for increasing food and intensifying the challenges related to agri-food waste management. As one of the innovative approaches to recover the resources lost along the production chain, the use of the larvae of the black soldier fly (BSFL), Hermetia illucens L. was mentioned, and its ability to grow and convert a wide range of organic waste materials into insect biomass.

The paper published aimed to provide a state-of-the-art review on the potential pretreatment methods that may improve the digestibility of substrates by BSFL and consequently the production of BSFL. Physical (e.g., mechanical and thermal), chemical (alkaline treatments), and biological (bacterial and fungal) treatments were included to these processes.

The article discusses how mechanical, chemical, and biological pretreatments may improve the black soldier fly larvae's (BSFL) ability to bioconvert lignocellulosic substrates. Authors mention these pretreatments have the potential to increase the effectiveness of BSFL digestion, much like composting and anaerobic digestion.

The authors suggest that further efforts should concentrate on creating general, substrate-specific process guidelines that take into account elements like particle size, temperature, and chemical dosage. It also stresses how crucial it is to comprehend pretreatments' impacts on the BSFL digesting process in greater detail. As well, researches suggest the future studies should examine how to improve the pretreatment procedure and how chemical pretreatments affect subsequent processing, such as the quality of feed and fertilizer products obtained from BSFL rearing.

The article's conclusion underlines the potential advantages of mechanical, chemical, and biological pretreatments in boosting the efficiency of BSFL's bioconversion of lignocellulosic substrates. In order to properly comprehend the consequences and viability of these pretreatment procedures in the production of BSFL-based products from agri-food wastes. The review made paves a further path for additional study, process optimization, and thorough analyses.

The article can be accessed online at the SUSINCHAIN project website along with other scientific publications.

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