Future potential of insect farming

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- Insect farming can convert lower-value by-products from the agri-food industries into high-value materials, such as proteins, thus offering a sustainable alternative solution for underexploited resources.
- Efficient insect farming and processing can allow holistic utilisation of insect biomass and by-products, thereby closing the nutrient loop applying the principles of circular economy.
- Insect frass is an effective organic fertiliser consisting of excrements and exoskeletons of insects.

The role of insects as a part of traditional diets is widespread among at least 2 billion people worldwide, with over 1900 species reportedly used as food. Insect farming is not a new practice and commercial mass production systems already exist in sericulture (silk production), apiculture (beekeeping), or to support the integrated and biological control of pests in agriculture. Insect farming draws parallels to that of conventional agricultural practices and is not very different from livestock production in the sense that both convert a source of nutrients (feed) into biomass. Despite the ubiquity of insect consumption in certain parts of world, insect farming is gaining more recognition than ever before and it is believed to be a sector with immense potential worldwide for a range of benefits.

Increasing numbers of consumers are changing their meat consumption habits by adopting a flexitarian diet and are generally more aware of food sourcing, sustainability and nutritional quality. This global shift in attitudes around food creates new opportunities for the insect food sector. Furthermore, the growing demand for high protein food for sport nutrition, dietetic food, or in food supplements creates further opportunities. Currently, these are niche markets but are forecasted to grow rapidly in the next few years.

Insect farming

Mass rearing of insects offers major opportunities for the large-scale production of protein for food and feed, with less environmental impact than animal production. Insect farming can offer socio-economic benefits for local businesses at any production scale. Locust (*Schistocerca gregaria*), cricket (*Acheta domesticus*), mealworm (*Tenenbrio molitor*), black

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soldier fly (*Hermetia illucens*) and common housefly (*Musca domestica*) larvae are now successfully farmed globally for food and feed purposes. Insect farming has grown further and these organisms are being produced on a large scale using vertical farming techniques. Aspire, a United States based edible insect business, uses precision-farming technologies including robotics, automation and sensor technology to monitor the insect rearing process. An efficient insect farm can utilise agricultural organic waste and by-products from the agri-food industries, converting these into high-value materials, such as proteins, oil and chitin. Insects are a high protein natural component of the diets of farm animals including fish, poultry and pigs. According to the existing EU legislation that the UK complies with, use of fat from insects is permitted to be used in feeding of all farmed animals, but processed animal proteins derived from farmed insects are only permitted for use in aquaculture. However, the possibility of extending the authorisation to poultry and pigs is under discussion. Chitin is a biodegradable polymer known to be a natural plant growth regulator and growth stimulant. Chitin has demonstrated beneficial effects as a fertiliser, soil conditioner and plant disease control agent. After the insects are harvested, considerable amounts of substrate residues and insect excrements (also known as frass) are left behind. Frass may have great potential as valuable organic biofertiliser by positively affecting soil fertility and crop yields. As sustainable agriculture becomes more urgent, integrating insect farming in traditional systems could be a promising strategy closing the nutrient loop applying the principles of circular economy.

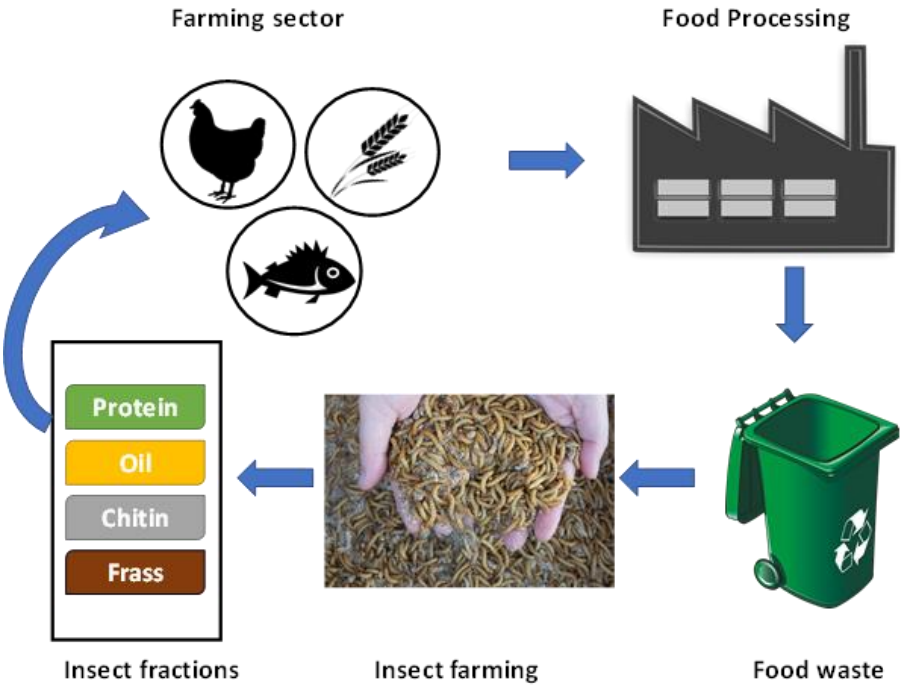

Fig1: Schematic representation of the insect-based integrated agriculture towards circular economy approach

Insect frass as a potential fertiliser

The use of organic or bio-fertilisers for agriculture has gained significant attention over chemical fertilisers due to various socio-economic and environmental issues. Organic fertilisers include a variety of plant-based materials that includes fresh or dried plant material, agricultural by-products and animal manures. The nutrient composition of organic fertilisers varies significantly depending upon the source materials. Hence, the development and application of new organic products with the ability to promote plant growth is a possible way to address the challenges of ensuring both an enhanced production and protected environment.

In nature, the deposition of insect excrement is well-known to affect the leaf litter decomposition process and nutrient dynamics in soil. Frass of herbivorous insects contains large amounts of nutrients in forms that are easily assimilated by plants. It can stimulate growth of natural soil microflora, which in turn increases soil respiration, decomposition rate and nitrogen mineralisation. These beneficial effects are dependent on the quality and

quantity of insect frass deposited to soil. Interestingly, the diet of an insect can drastically modify the properties of the frass produced. There are several studies suggesting the possible use of insect excrement from different insects including grasshoppers and cabbage moths as organic fertilisers. In addition, other studies have shown how the intestinal microbiota of different insects, like the diamondback moth (*Plutella xylostella*), can contain microbes that act as plant growth promoting microorganisms. Many of these microbes can fix atmospheric nitrogen, promote mineral absorption and produce plant growth promoting chemicals in soil.

Although frass has shown greater potential as a biofertiliser, there is only a limited understanding of how this biofertiliser might impact upon plant growth and soil fertility and most importantly whether these effects are consistent. Insect farming in controlled environment systems is essential to ensure quality, safety, traceability and consistency of the insect-based products including insect frass. Recently, a research group in Spain reported the potential of yellow mealworm (*Tenebrio molitor*) frass as a biofertiliser in organic farming. In this study, insects were fed on different types of food producing excrement with different compositions. The study compared the potential effect of the excrement on plant growth promotion and tested its potential to increase tolerance to abiotic stresses such as drought, excess water and salinity. The best results were obtained when the insects were fed a diet low in fat and starch content. The analysis of the microbiome through massive parallel sequencing, as well as the analysis of the capacity of several microbial isolates to promote plant growth, showed that several microorganisms present in the excrement are plant growth promoters. The results from this study demonstrates that the frass produced by mealworms not only have superior nutritional content, but also has a strong influence on microbiota associated with frass.

Summary

With fast increasing global demand for food, particularly protein, insect farming has drawn considerable attention for sustainable and high-quality protein to feed the world's growing population. Today, insect protein is used in fish feed and potential has been demonstrated for poultry feed and other livestock. Insects are an excellent source of protein, essential amino acids, omega 3 fatty acids, vitamins and minerals and have clear potential of becoming the next superfood. Insect protein has successfully been incorporated in snacks, protein bars and powder by several companies. In the EU, insects fall into the "novel foods" category, and have to be authorised under the novel food regulation. From January 2018, the new Novel Food law is in place, which has harmonised and simplified the approval process to a certain

extent. Insect farming is a more effective way of converting feed material into utilisable protein than most other forms of livestock farming. Insect farming also generates considerably less greenhouse gases, which may become increasingly important in the future. Frass, a co-product of insect farming, can be potentially used as a biofertiliser in farming and would contribute significantly to closing the loop of circular economy concept.

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