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Edible insects: non-food and non-feed industrial applications

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EDITORIAL

Abstract

Edible insects can be considered for applications other than food or feed. This may be the case when biodegradation is the main purpose and food safety issues are a concern. Multi-purpose applications will also make edible insects more interesting for mass production.

1. Introduction

The cochineal, the scale insect *Dactylopius coccus* (Hemiptera: Dactylopiidae), is well-known as being edible, but it is also used in industrial processes. This insect is reared for marketing purposes on *Opuntia* sp. cactuses of which Peru is the largest producer. The female insect produces a colorant (E120) of which carminic acid is the active ingredient. It is used in many industrial applications such as: (1) the food industry (e.g. gelatines and jams); (2) the pharmaceutical industry (e.g. syrups, toothpastes); (3) the cosmetics industry (e.g. lipsticks); (4) the textile industry (e.g. for dying wool and silk) (De Jesús Méndez-Gallegos *et al.*, 2003). The production of carminic acid using engineered microorganisms has also been attempted (Seo and Jin, 2022).

Insects may be used as feed but can also be considered as food, such as is the case with the black soldier fly (Bessa *et al.*, 2020). Cockroaches are considered more as feed but can also be consumed by humans (Ukoroije and Bawo, 2020). The other way round is easier as most insects used as food can also be used as feed. Edible insects can also be used for cultural purposes (medicinal, toys, depicted on stamps, etc.); e.g. Van Huis (2021). However, I would like to concentrate on the industrial applications.

2. Oil products

Vegetable oil is normally used for the preparation of skincare and protection products. However, lipids derived from insects can also be used for this purpose. The high concentration of lauric acid in black soldier fly larvae (BSFL) seems to make it less suitable in skincare production than locust or cricket fats, which are rich in C16 and C18 fatty acids (Verheyen *et al.*, 2018). This last publication also indicated some challenges such as the high phospholipid and free fatty acid levels as well as odour and colour. According to Franco *et al.* (2022) the composition of the fatty acids in BSFL is favourable for soap production, while their derivatives can be used for detergent and shampoo production. They mentioned that skincare products produced by using purified BSFL fat are already on the market. Verheyen *et al.* (2020) demonstrated that BSFL fats could be a promising and suitable alternative to palm kernel or coconut oil for the synthesis of glycine-acyl surfactants, which can be used for technical applications (such as detergents, wetting agents, emulsifiers, and foaming agents).

There are many publications dealing with the production of biodiesel from fats of BSFL. For example, in Malaysia this is done by feeding BSFL on fermented (using the fungus *Rhizopus oligosporus*) palm kernel expeller leftovers (Liew *et al.*, 2022). The highest yield of biodiesel obtained from BSFL fed with organic waste was more than 80% (Park *et al.*, 2022). Biodiesel is often produced by the enzymatic transesterification of oil or fat with methanol (Wong *et al.*, 2020), and it has been produced using different insects, mostly BSFL (Surendra *et al.*, 2016), but also the yellow mealworm (Lee *et al.*, 2021a; Wang *et al.*, 2017; Zheng *et al.*, 2013), and the palm weevil *Rhynchophorus phoenicis* (Tangka *et al.*, 2020). Different organic side streams are used, but manure is also an interesting substrate (Lee *et al.*, 2021b; Li *et al.*, 2011).

3. Protein products

Proteins isolated by extraction from black soldier fly prepupae and dissolved in water with the addition of glycerine show a highly functional potential as a polymer matrix for film formation. They can successfully be employed as a base for bio compostable plastics in agriculture (Barbi *et al.*, 2019).

4. Chitin products

Chitin is, after cellulose, the most abundant biopolymer. The major sources of chitin are crustaceans, insects and microorganisms. Chitin and chitosan, the deacetylated derivative of chitin, have a widespread application in nutrition and biomedicine. They exert anti-cancer, antioxidant and antimicrobial functions, and can also be used for tissue engineering, biomedicine, wound healing processes, microencapsulation and sustained drug delivery applications (Jacob *et al.*, 2020; Tripathi and Singh, 2018). Chitinases are employed in antifungal creams and lotions, while chitin derivatives have a number of applications such as in the making of contact lenses, artificial skin, and surgical stitches (Singh *et al.*, 2022). The black soldier fly's pupal exuviae are used, as they yield the most chitin and chitosan and these can easily be supplied by insect farms (Triunfo *et al.*, 2022).

5. Antimicrobial peptides

Insects are extremely resistant to bacterial infections and are a primary source of antimicrobial compounds (Hadj Saadoun *et al.*, 2022). There is great potential for their use in livestock production as there is an increasing problem of antibiotic resistance, and alternatives to antibiotics would be desirable (Józefiak and Engberg, 2017). These insect peptides exhibit an antimicrobial effect by disrupting the microbial membrane and consequently it is not easy for microbes to develop drug resistance. At present, several structural families of Antimicrobial peptides (AMPs) from insects are known (defensins, cecropins, drosocins, attacins, diptericins, ponericins, metchnikowins, and melittin), but new AMPs are continuously being discovered (Wu *et al.*, 2018). Several AMPs have been identified in the black soldier fly (Xia *et al.*, 2021; Zhang *et al.*, 2021), but research is at an early stage and more studies are required (Xia *et al.*, 2021).

6. Biodegradation of plastics

Foam plastics of polystyrene, polyethylene, polypropylene, polyurethane, polylactic acid and polyvinyl chloride, can be degraded by yellow mealworms (*Tenebrio molitor*) and superworms (*Zophobas morio*) (Wang *et al.*, 2022). The degrading of polystyrene and polyurethane by both these species was associated with distinct microbiomes (a number of genera of bacteria were mentioned) although similar changes in chemical groups in plastics have been observed (Wang *et al.*, 2022). Kuan *et al.* (2022) showed that yellow mealworm, the superworm and *Galleria mellonella* utilise polystyrene and polyethylene for mineralisation as a carbon source. They identified some bacteria such as *Pseudomonas aeruginosa* in the superworm as the cause of polystyrene degradation.

7. Bioremediation

Bioremediation is a process that employs living organisms to remove contaminants, pollutants, and toxins from soil, water, and other environments. Bulak *et al.* (2018) used black soldier fly larvae to reduce the dry mass of cadmium (Cd) and zinc (Zn) in polluted corn leaves by about half after 36 days. Cd accumulates mostly in the puparia, while Zn accumulates in the adults. The high Cd content in the puparia might facilitate the recovery of the metal. Sverguzova *et al.* (2021) reduced Cd by close to 75% in zoo compost by using the black soldier fly.

Antibiotics such as oxytetracycline (Liu *et al.*, 2020) and ciprofloxacin found in poultry manure can also be removed by black fly larvae, (Yang *et al.*, 2021) and intestinal microorganisms facilitate bioremediation.

8. Other applications

The defence chemical of the edible stinkbug *Encosternum delegorguei* in Malawi is removed using a water method (e.g., pouring hot water over the stinkbug). The insect is eaten and the drained water can be used as a termiticide (Dzerefos *et al.*, 2013).

9. Conclusions

The question is whether consumers are willing to use insect-based non-food products, such as cosmetics. Lenaerts *et al.* (2019) found that both novelty seekers and risk avoiders are willing to try, but it depends on the product. Where food safety issues are concerned, non-food and non-feed applications may be an interesting alternative.

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