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Towards sustainable nutrition: could mealworms provide a solution?

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Mealworms are insects with a high nutritional value and could provide a source of animal protein that is more sustainable than traditional livestock.

With the human population reaching new highs every year and expected to reach 10 000 million by 2050, the demand for food, especially animal protein, is steadily increasing.[1] However, most of the traditional livestock consumed by humans have large water and carbon footprints and require a lot of agricultural land. The production of livestock feed generally has a much greater environmental impact that the direct water and land requirements of the animals, and loss of biodiversity is also associated with use of land for the production of animal feed. This makes it crucial to explore more sustainable alternatives, such as mealworms. Mealworms (figure 1) are edible insects that are packed with high-quality proteins, essential amino acids, beneficial fatty acids, and valuable micronutrients.[2] Mealworms also have a smaller ecological footprint compared with conventional livestock, which makes them an excellent option for a nutritious and eco-friendly addition to our diets.[1, 3]

Figure 1: Frozen mealworm larvae
Image courtesy of the authors and the photographer Maks Sešlar

What exactly are mealworms?

Mealworms are not worms at all, but the larvae of mealworm beetles: black-brown beetles measuring approximately 13–16 mm in length with an oval-shaped body. The larva (mealworms) are yellowish gold in colour and can reach a length of up to 25 mm. The beetles undergo a developmental cycle like that of butterflies, known as complete metamorphosis (figure 2), which comprises four distinct life stages. The beetles originally come from Eurasia but have spread through the world because of human activity.[4] They can often be found as pests in stored food.[5]

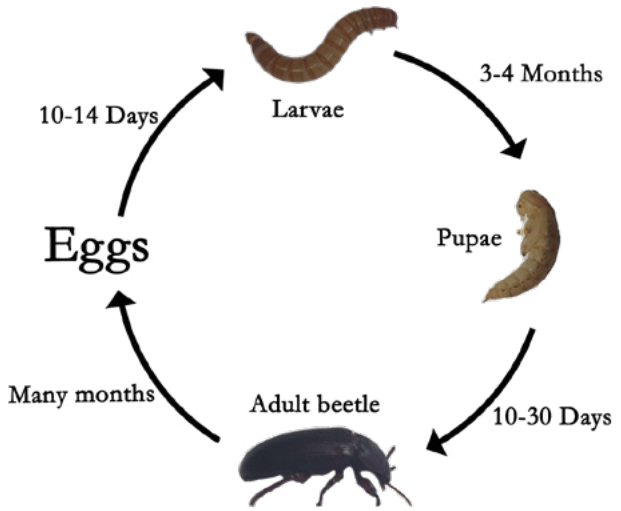

Figure 2: The four distinct life stages of the mealworm. The female beetle lays around 500 eggs, from which emerge young larvae (mealworms). The larvae will spend around 3–4 months eating, shedding, and growing. After that, they become pupae for around 10–30 days, during which time they undergo metamorphosis and transform into adult beetles.[4]

Image courtesy of the authors, adapted from Ref. [6]

Mealworms as food

Insects (especially their larvae) are treated as everyday food in many different cultures around the globe, such as mopane worms in Zimbabwe, termites in Kenya, and grasshoppers in Mexico,[7] and are often considered as delicacies – not only because of their taste but also because of their high nutritional value.[2] Mealworms were first used as feed for exotic animals, but in recent years they have garnered attention for human consumption as a sustainable alternative to current protein sources. Of all the different species available, mealworm beetles (*T. molitor*, figure 3) has proven to be the most suitable for commercial farming.[5]

Mealworms have many potential benefits as a food source. They can efficiently convert food waste into edible protein and have a very high nutritional value. Moreover, they also have a significantly lower ecological impact than traditional livestock; they have much lower water and land requirements, their greenhouse gas emissions are lower, and they have superior feed-to-protein conversion rations compared with pigs, cows, and poultry.[3] Mealworms can have a feed conversion ratio (FCR: the weight of feed consumed divided by the weight gained by the animal) as low as 2.2 but it depends heavily on the feed and life stage.[3] For perspective, in cattle the FCR number is considerably higher, averaging about 8.52.[8] Furthermore, mealworms are commonly fed wheat bran, which is a by-product of the wheat industry, and can also be grown on other organic waste. Mealworms do not require a lot of space, and because of that they can be grown vertically with a minimal carbon dioxide (CO_2) footprint, as has been already demonstrated by some companies.[9]

Figure 3: A beetle rearing box (left), and oven-dried mealworms (right).

Images courtesy of the authors and photographer Maks Sešlar

How nutritious are they really?

It is tempting to think that mealworms must be nutritionally inferior to red meat, but in fact they are incredibly nutritious.[2, 10–13] They provide more calories and more protein per 100g than conventional meat (figure 4 a,b), and they are not just a protein-packed snack but also full of other micronutrients (figure 4 c).

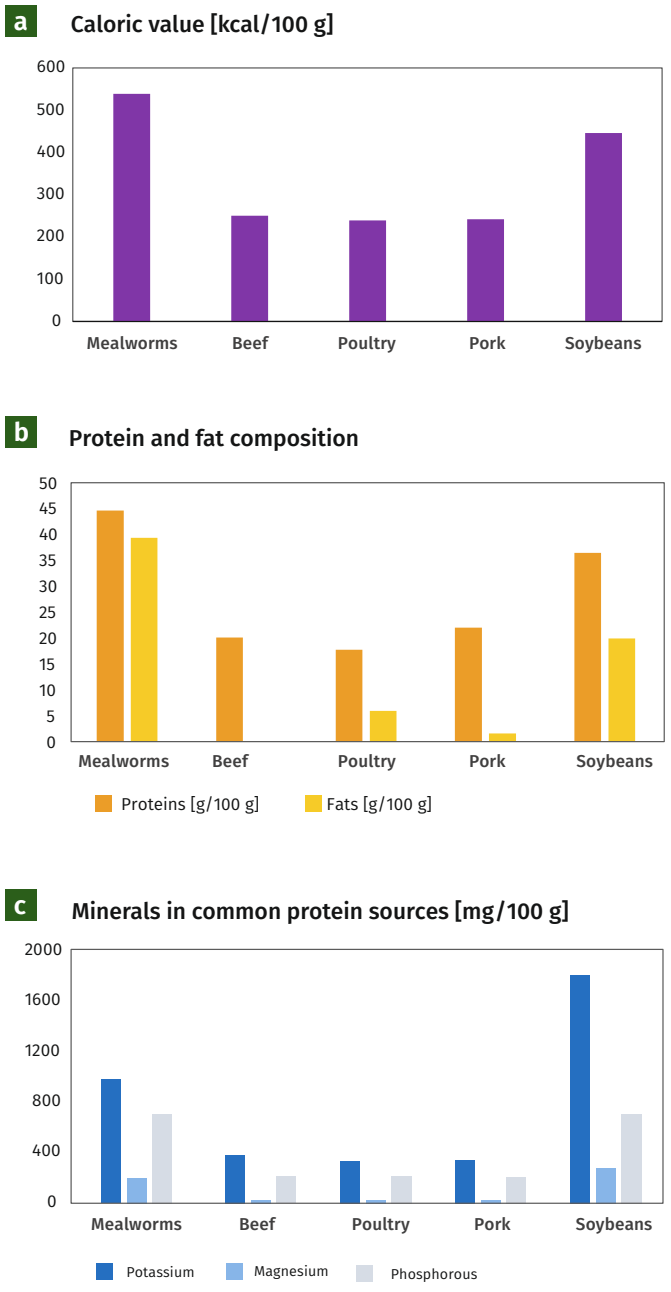

Figure 4: a) The average caloric value of mealworm compared with other protein sources. b) Comparison of protein and fat content. c) Comparison of mineral composition.

Images courtesy of the authors, data from Ref. [2, 10–13]

In addition to minerals, mealworms contain a lot of important fatty acids, such as oleic acid, palmitic acid, linoleic acid, and omega-3 and omega-6 fatty acids[2]. When comparing mealworms to plant protein, such as soybeans, we can see that soybeans are also a great source of many vital nutrients. Although there are environmental issues with soybeans too – in particular, the conversion of forest and other valuable habitats into farmland to grow soy intensively for animal feed[14] – they have a lower ecological impact than animal-based protein. That said, a simple comparison of the protein and fat content to animal-based protein doesn't tell the full story since the precise amino acid and fatty acid composition differs substantially. Mealworms contain all the essential amino acids, although the digestibility of insect protein is somewhat lower than protein from vertebrate animals. Due to their exoskeletons, mealworms also contain indigestible fibre in the form of chitin, which is also found in mushrooms,[15] and there is some evidence that this could promote healthy gut bacteria.[11]

From mealworms to meals

Mealworms are a versatile food, as they can be incorporated in basically anything from protein bars to whole dishes. They possess a mild, nutty flavour, and can be served whole or dried and ground into a flour that can be added to baked goods to increase the protein content and caloric value. In our own kitchen we have prepared delicious protein bars, Pad Thai, scrambled eggs, and cookies with mealworms or mealworm flour (figure 4).

Figure 4: a) Pad Thai made with mealworms as a substitute to chicken. b) American-style cookies made with home-made mealworm flour.

Images courtesy of the authors and the photographer Maks Sešlar

Presenting mealworms as either an alternative to meat or a dietary supplement is still challenging because of their looks – many people are disgusted by them. This problem can be overcome with the use of insect flours, which make mealworms almost invisible when incorporated in a dish. However, it is crucial to recognize the urgent need for sustainable solutions to mitigate the environmental impact of conventional meat production. By shifting our perspective and overcoming prejudices, we can incorporate mealworms and other alternatives to conventional meat into our diets as a way to reduce our ecological footprint. Embracing more sustainable and compassionate food systems is essential for the long-term well-being of both the planet and future generations.[11, 16]

What about their waste?

Mealworms are not only protein-packed, but are also praised for their outstanding fertilizing capabilities. Their excretions, called frass (figure 5), are full of nitrogen (N), potassium (K), phosphates (P), and other micronutrients that are essential for the growth of plants, and are a perfect organic substitute for mineral NPK fertilizers, while also being produced sustainably and leaving a smaller impact on the soil.[1]

Figure 5: Mealworms and their frass
Image courtesy of the authors and the photographer Maks Sešlar

Conclusion

Mealworms have proven to be an outstanding insect that could help address the ever-increasing demand for animal protein while using less space, water, and feed than conventional livestock and producing an excellent organic fertilizer as a waste product. So if you get the chance to try mealworms, leave behind your prejudice and see what they have to offer! «

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Resources

- Read an article from the Food and Agriculture Organization of the United Nations (FAO) on the potential of edible insects
- Read about a research project to produce a range of tasty seasonings from mealworms, and learn how different cooking methods change the flavour.
- Try growing mealworms in the classroom to learn about metamorphosis.
- If you have access to food-grade mealworms, dare to try a mealworm recipe
- Read about the impacts of meat consumption and the development of lab-grown substitutes: Noble M (2023) From Petri dish to plate: the journey of cultivated meat. *Science in School* **63**.
- Read an article about the environmental effects of food packaging: Barlow C (2022) Plastic food packaging: simply awful, or is it more complicated? *Science in School* **56**.
- Learn about the feuds between plants and pathogens that span millions of years: Harant A, Pai H, Cerfonteyn M (2023) Plant pathology: plants can get sick too! *Science in School* **63**.
- Teach your students about our water footprint: Kelly S (2020) Do you know your water footprint? *Science in School* **50**.
- Investigate the properties of so-called superfoods: Frerichs N, Ahmad S (2020) Are 'superfoods' really so super? *Science in School* **49**: 38–42.
- Investigate food chemistry with mushrooms: Bunjes F et al. (2017) Natural experiments: chemistry with mushrooms. *Science in School* **42**: 36–41.
- Introduce the biology of bees and the biochemistry of honey with these teaching activities: Scheuber T (2023) To bee or not to bee: the biology of bees and the biochemistry of honey. *Science in School* **49**: 38–42.

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