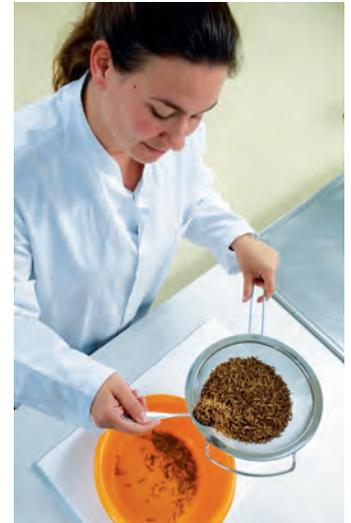


Mealworm Products With Custom-Made Texture

Due to the environmental impact of animal meat such as beef, pork and poultry, a need for alternative protein sources and meat substitutes is growing. Insects seem to provide the optimal alternative.

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What seemed like a futuristic idea only recently has now become reality: insects as food ingredients. More and more food companies are looking into the possibilities of using insects as ingredients in their food. Experts at Wageningen University & Research are making the choice of suitable insect species easier with their inventory of nutrients. Their research shows that yellow mealworm paste can be produced with diverse textures, which offers possibilities for the development of products like insect burgers and spreads.

A growing global population is creating a growing demand for proteins and meat. Due to the environmental impact of animal meat such as beef, pork and poultry, a need for alternative protein sources and meat substitutes is growing. Insects seem to provide the optimal alterna-

tive. The amino acid composition of many edible insects is similar to that of meat, especially when it comes to essential amino acids. On top of that, insect lipids are composed of a high content of unsaturated fatty acids, meaning that they are healthier than conventional meat, which is rich in less healthy saturated fatty acids. Furthermore, the environmental impact of insects, such as feed conversion rate, ammonia and methane emissions, and CO₂ footprint, is significantly lower than that of usual livestock.

Choice of Insects

Grasshopper, larvae of black soldier fly or mealworm beetle? Of all the edible insects available, which one should we choose as a food or food ingredient? Insects are very diverse, and within each species, there is a large difference in composition de-

pending on their developmental stage: eggs, larvae, pupae and adults.

Depending on the intended application, a high, medium, or low content of protein, fat, or chitin is advisable and should direct the product developer's or scientist's choice. When looking for an insect that would be used as a whole or as a flour or paste, it is more important to choose an insect that is rich in both protein and fat, and low or moderate in chitin, as chitin-rich parts of the insects are uncomfortable to chew on.

Insect Inventory

To assist in making the right choice, a Wageningen University (WUR) team created an inventory of hundreds of edible insects reported in scientific literature and plotted their contents of protein, fat and chitin. An example can be seen in figure 1, which

shows protein and chitin contents in different insects. The highlighted section in this figure shows the top 20 edible insects that are high in protein and low in chitin concentrations. One of the most favorable insects from this group is the silk worm, *Bombyx mori*, which makes a great choice for protein extraction, with almost 70% protein. The silk worm can also be eaten as is. For example, in Vietnam, these side-products of silk production are consumed with spices and sauce. Another interesting insect is the yellow mealworm, *Tenebrio molitor* – which is the larvae of the mealworm beetle, which can be used as a whole with a reasonable fat (circa 40%) and protein (circa 50%) content, which is low in chitin.

Insect Product Innovation

Keeping the environmental and nutritional reasons in mind, edible insects seem to be an ideal alternative to meat, if it weren't for the legs and the wings and the creepy-crawly attributes that make them less acceptable as food for Western consumers. Then again, almost one-third of the world's population eats insects on a regular basis. The market for insects is emerging. What kind of commercial insect products have been launched in recent years?

As the so-called worms, which are in fact the larvae of insects, have a high protein and fat content and are low in chitin, this group became the focus of our Innova Database search.

We basically found three categories of worm products:

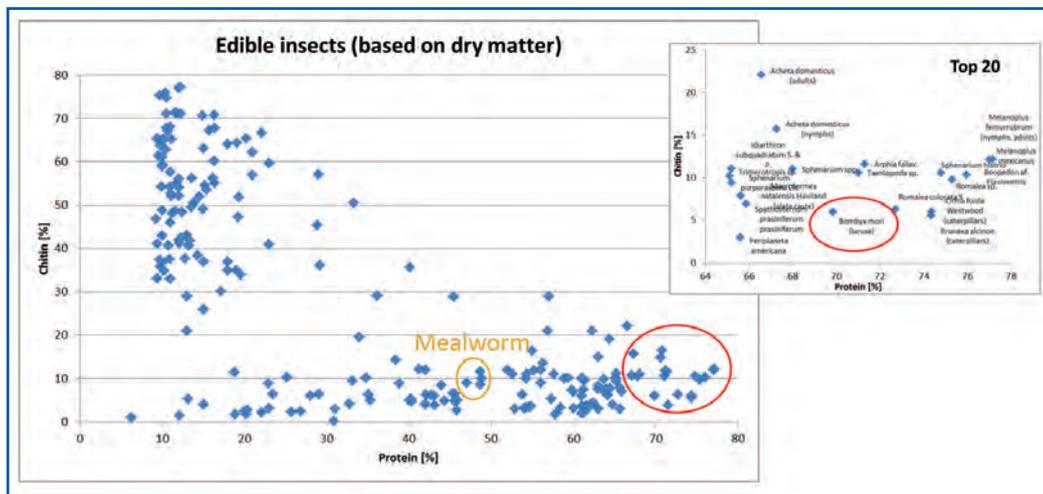


Figure 1: Edible insects sorted by protein and chitin content.

- Dried whole worms as pet food;
- Dried and seasoned worms, as snacks or seasoning, and;
- Processed worms as ingredients in spreads and meat alternatives.

The first category, pet food, is neglected here in this particular food context. The second category, snacks and seasoning, has the smallest portion size and the highest price per kilogram. For example, flavored mealworm crisps used as a fancy snack cost more than €150/kg, with portion sizes of circa 20g. These products are clearly niche products, as they are too high in price or are consumed in too little amounts to be relevant for nutrition. The third category, processed worms as ingredients, is very interesting from a nutritional point of view. Additionally,

the worms are unrecognizable in food products, which will increase the chance of acceptance by western society. In mealworm spreads, the main components are vegetables and vegetable oil, whereas mealworms account for only 4-6% of the ingredients. Meat alternatives such as schnitzels, vegetable-based burgers or nuggets contain 14% buffalo worm which is relatively high, as it is listed as a second ingredient after water. These non-vegetarian meat alternatives, therefore, represent products with a more substantial insect content. Overall, the number of insect food products is quite small. As for making insects substantial replacers of our common animal proteins, processed worms as ingredients in spreads and meat alternatives are the most promising.



Figure 2: Baked mealworm paste is dark brown for fresh and 250-300 MPa, compared to light brown for 400-500 MPa and light brown for blanched treatment.

▼ Aspects of Insects as Food Ingredients

In addition to nutrient content, other aspects of insects have to be taken into account for their use as food ingredients as well:

- Productivity and possibility for mass-rearing
- Insects should feed on substrates free from pathogenic microorganisms and toxic compounds, as they might accumulate them.
- Allergenicity – The allergenicity of insects is an aspect which has not sufficiently been researched yet for most species, and which should be labeled when known. People allergic to crustaceans or house dust mites might be allergic to some insects as well.
- Legal status – At the end of 2015, the EU decided that insects have to go through a Novel Food regulation process, although national exceptions do exist. ▼

Technical Challenges

In order to use insects as food ingredients, among others (see outbox), two hurdles have to be overcome: microbial safety and browning. Browning of mealworms occurs due to the presence of the enzyme polyphenoloxidase. WUR performed experiments with yellow mealworms (*Tenebrio molitor*), addressing these two aspects, followed by an investigation of texturization.

In our experiments, different blanching and high-pressure treatments – a relatively new mild preservation technique – were tested on whole mealworms. The mealworms were then ground into a paste in order to evaluate the effect of the treatments on browning. The best conditions that prevented browning were:

Short blanching with a peak temperature of 80°C, or;

High-pressure treatment with pressures of > 400 MPa (4,000 bar).

The side effect of blanching is a softly textured mealworm paste, whereas high-pressure treatment resulted in a harder and drier texture. Browning could also be prevented by the use of air-tight packaging.

Custom-Made Texture

Combining the results of blanching and high-pressure treatments allows us to tailor the texture of the mealworm product. For a spread, the color should be light and the texture soft. Therefore blanching is the best method.

For a burger, browning and a firmer texture are desirable, so the advice is high-pressure treatment at 400 MPa (4,000 bar). Another op-

tion would be no treatment at all. In this case, microbial safety can be assured by heating the mealworm burger in the pan.

A burger should be somewhat crumbly and release some moisture, but not too much. Both mealworm burgers meet these requirements. A pâté type of texture can also be achieved with mealworms when high-pressure treatment at 500 MPa (5,000 bar) is applied.

Compared to real pâté, which is mostly made of pork meat, liver and fat, an additional advantage is that the surface layer stays fresh for at least 3 weeks. In laboratory tests, high pressure treated mealworms showed an appealing orange/light brown color, and the aroma of mealworm paste was savory, with a mushroom and nutty note. Upon baking, the aroma even intensified.

These properties, combined with excellent nutritional values, supports our belief that mealworm paste has a future as a food ingredient on the non-vegetarian meat replacer market. ▼

Wibke Roland, Lenka Tonneijck-Srpova, Nam-Phuong Humblet-Hua and Marieke Bruins conduct applied research in the Food Technology group of Wageningen Food and Biobased Research, mainly on request of food companies. The mealworm research was performed within the STW In2Food project - Production and valorization of high proteins from insects. For more information about product development with insects, please contact Marieke Bruins: marieke.bruins@wur.nl

