Insect revolution

Healthy, sustainable, protein rich and delicious

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Worldwide, the demand regarding alternative protein carriers is increasing due to the growing world population. In this context, insects and the resulting industrial developments are particularly noteworthy.

Globally, the development of a newly emerging branch of industry dealing with the fattening and rearing of insects as well as the development or automation of the associated machinery and plant engineering can be observed.

For this reason, the German Research Institute of Feed Technology (IFF) organised a three-day online event under the topic "Insect revolution! Healthy, sustainable, protein rich and delicious."

A proud total of 15 nations from three continents participated in this event, with a series presentations and discussions covering the following current topics including legal framework, insects in general, the husbandry and harvesting of insects, how to process them into protein meals and lipids and the properties of these products. The programme also covered animal nutritional aspects, sustainability and economic viability.

Legal framework

The regulatory framework and the estimated future market potential of this newly developing industry was presented in the opening event. As the Statista infographic shows, sales of edible insects alone are forecast to increase significantly in all regions of the world by 2023. The entire global market would then turn over more than one US$1billion (Figure 1).

But in line with the market potential, the legal foundations have to be determined first. In June of the last year, the International Platform of Insects for Food and Feed (IPIFF) gave a brief outlook on the rapidly developing new industry and pointed out, among other things, the legal situation in the EU, which differs from the international market (Figure 2).

In order to be able to produce and sell a product in a way that creates value, the first step is to obtain legal approval for it. On the part of the EU, insects were included in the group of animal by-products with Regulation (EU) No. 2017/893.

Thus, with the amendment of Regulation (EC) No 999/2002 and Regulation (EU) No 142/2011, insects were allowed to be fed to fish in aquaculture since 2017 and accordingly are defined as farm animals.

This includes the lifting of the ban on feeding insects to pigs and poultry, which resulted from the BSE crisis 20 years ago. Approval for these two target animal species can be expected by autumn of this year, as only then the EU Parliament will finally discuss the proposal.

However, insects can be used innovatively not only in the feed industry – which includes the pet food industry – but also in the food industry, as Figure 1 illustrates.

As of January 1, 2018, the Novel Food Regulation (EU) 2015/2283 came into force. Here, the whole insect and parts of insects as well as ingredients derived from insects are considered as novel foods and must be health assessed and approved before being placed on the market.

The current relevance of the topic "insects" is reflected, among other things, in the fact that for the first time the EU states have approved a proposal by the European Commission to authorise dried yellow mealworms as a novel food in the EU, as of May 4, 2021. This is the first approval of an insect as a novel food on the EU market.

Rearing & harvesting

However, from the hatching of larvae to the finished end product in the feed or food industry, many process steps and boundary conditions have to be considered (Figure 3). In addition to the choice of location, which is essential for substrate procurement and delivery of the corresponding insect species, the parameters of air conditioning and the life cycle, and coupled to this the harvest time of the insects, play a decisive role.

All companies use boxes of various sizes in adapted shelving systems for rearing or fattening the larvae. The larvae grow in these containers and must be fed according to their growth stages.

Adapted to the insect species and the requirements of the subsequent user, there are therefore many variation parameters that influence the generation/growth times as well as the harvesting times. For instance, the growth time of the mealworm, which is the larval form of the mealworm beetle (Tenebrio molitor), can be approximately 80 days.

Depending on the substrate to be fed and the harvest time, the body composition of the larvae may change if, for example, the composition varies in protein, fat, chitin, as well as water contents as in Figure 4, which shows the life cycle of the mealworm beetle.

Following Figure 3, the aspects logistics, air conditioning and harvesting to consider can also be represented as in Figure 5.

The area outlined in dashed lines deals with the living insect - eggs, larvae and beetles, in mealworm production. Companies operating in this area on the European market include Ynsect in

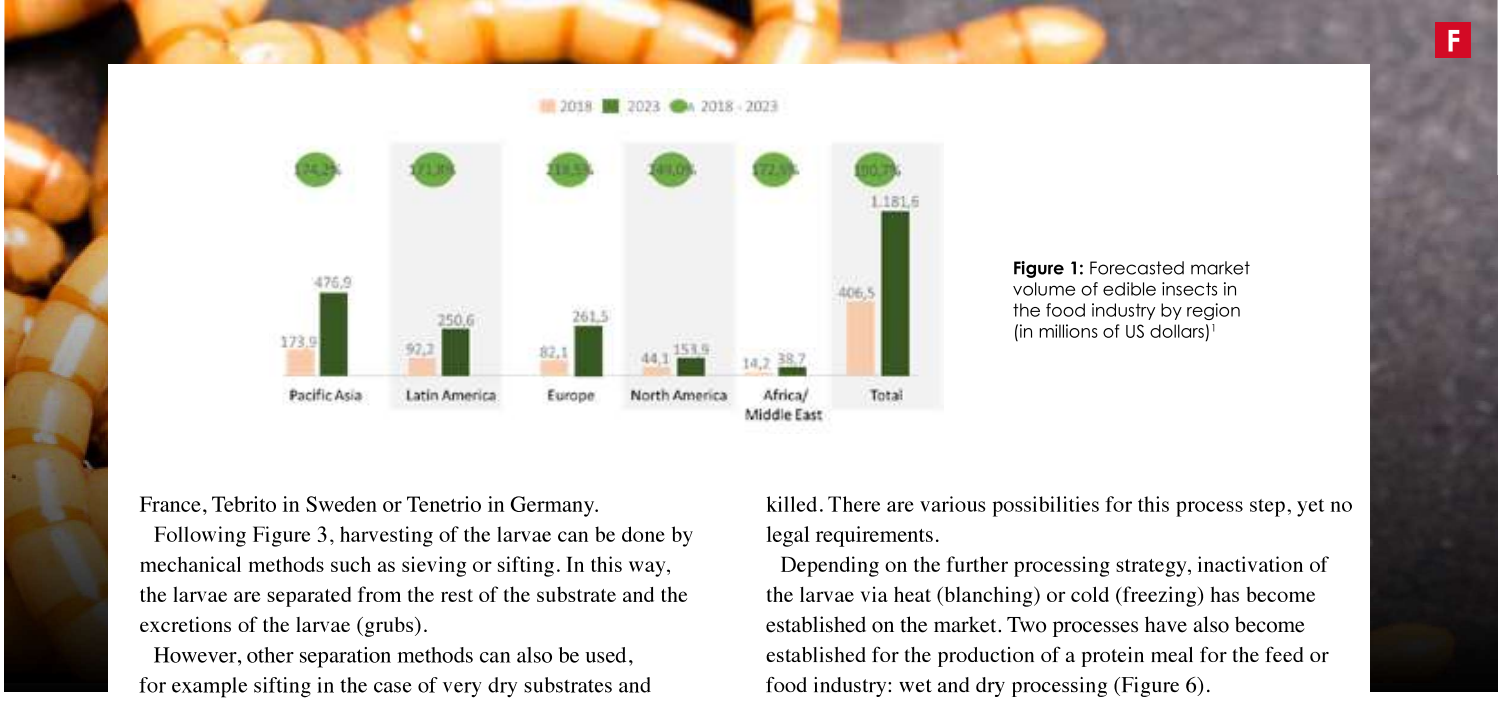

Figure 1: Forecasted market volume of edible insects in the food industry by region (in millions of US dollars)[1]

France, Tebrito in Sweden or Tenetrio in Germany.

Following Figure 3, harvesting of the larvae can be done by mechanical methods such as sieving or sifting. In this way, the larvae are separated from the rest of the substrate and the excretions of the larvae (grubs).

However, other separation methods can also be used, for example sifting in the case of very dry substrates and corresponding differences in density.

For the small animal or reptile market, the process chain is completed at this point and the larvae are fed alive. This option also exists in livestock production (pigs, poultry, fish) and is legally permissible (Figure 2).

Processing of insects

However, for accurate recipe design in the livestock sector or in the food industry, it is beneficial to convert the larvae into their value-determining components such as protein and fat. For further processing, the larvae must therefore be inactivated or killed. There are various possibilities for this process step, yet no legal requirements.

Depending on the further processing strategy, inactivation of the larvae via heat (blanching) or cold (freezing) has become established on the market. Two processes have also become established for the production of a protein meal for the feed or food industry: wet and dry processing (Figure 6).

At the end of the process chains, in both cases (wet and dry processing), there is a protein meal and a lipid (fat). However, depending on the preparation strategy, the properties of the end products differ.

The properties include, for example, the colour of the protein carrier, the composition of the crude protein due to the amino acids, the varying residual fat contents or the storage stability of the products. With regard to the lipids resulting from the processes, there are similar differences in properties such as colour and storage stability, to name a few.

However, the properties of the protein meals or lipids are of

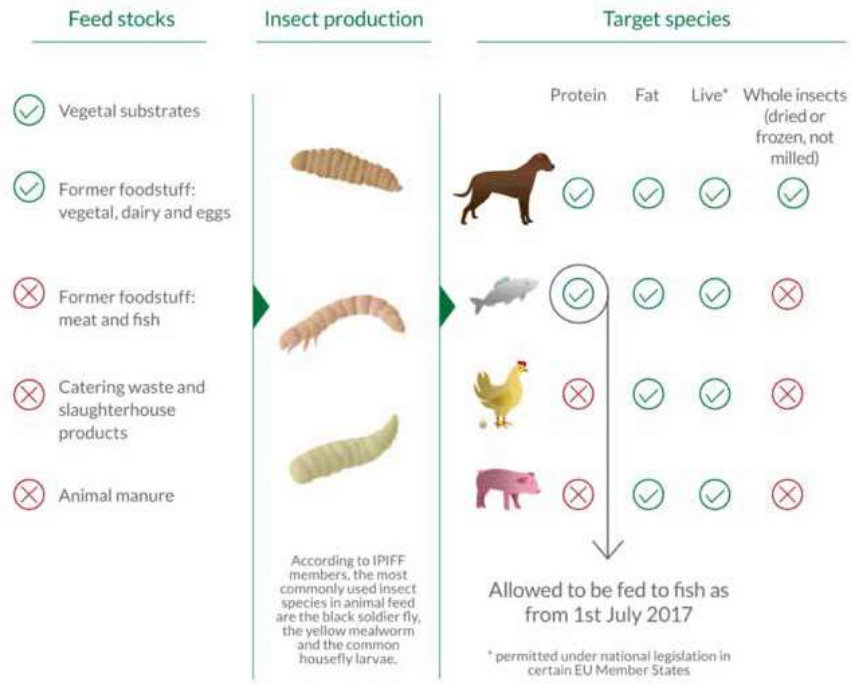

Figure 2: Legal framework for insects in the EU[2]

decisive importance for further use, for example in the compound-feed industry. For example, the residual fat content in the protein meal has a significant influence on further use. Residual fat contents of less than 10 percent in the dry matter are advantageous for optimum formulation design. Yet a dried fly larva or mealworm can have a final fat content of 25-40 percent depending on the substrate fed. Therefore, the different processing methods are used to reduce the fat content in the protein meals.

Figure 3: Possible influencing factors and boundary conditions in insect farming

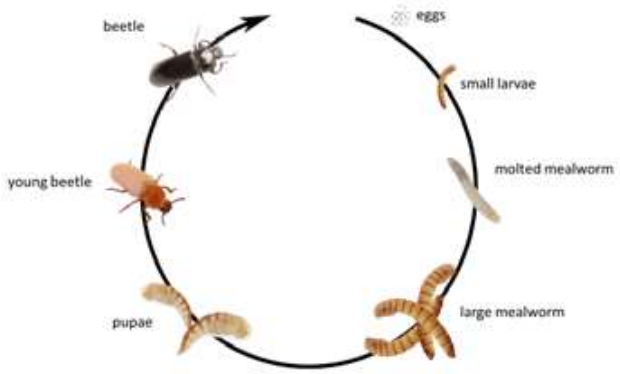

Figure 4: Life cycle of the mealworm beetle[3]

Properties & use

Assuming the use in the feed industry, the influence of the residual fat content in the protein meal will be examined in more detail on the basis of an example.

In the feed industry, about 80 percent of the goods are pelletised. The factors influencing pelleting are shown in Figure 7.

In the compound-feed formulation, which is to be pelleted, the residual fat content of the protein meal comes under the chemical material properties into effect. The total fat content of the formulation remains constant, only the composition of the fat-containing components in the compound-feed formulation changes.

In the industrial collective research project for SME "Functional model of an industrial production and fractionation plant (protein, fat) of insects" which was funded by the German Federal Ministry for Economic Affairs and Energy via the German Federation of Industrial Research Associations (AiF), the soybean extraction meal was replaced by a mealworm meal at 25, 50 and 75 percent in a pig feed formulation at the IFF (Table 1).

Due to the residual fat content of 5.5 percent, which was higher than that of the soybean meal used (3%), the addition of soybean oil was thereby reduced in the formulation. The total fat content of the formulation remained constant.

As the proportion of the mealworm meal is increased, the pellet quality increased -lower abrasion values and increasing hardness

of the pellets produced were measured, for example.

The use of the new straight feed (mealworm meal) thus had a clear influence on the subsequent process, pelleting, under otherwise constant conditions.

Sustainability and economic efficiency

Besides the production of alternative protein carriers, another aspect of the topic of insects is the global challenge to produce them in a way that does not result in negative consequences for the environment and climate.

The general assumption is that insects can be produced in a climate-friendly, space- and resource-efficient way (Figure 8). Feed conversion is considered good, so under optimal conditions 0.8kg of insects can be produced from one kilogram of feed[4].

However, since insects are considered as livestock by the feed law, they must also be fed approved feeds accordingly. Due to this, a competitive situation with conventional livestock farming arises. Only when insects are fed sustainably, the positive characteristics, such as the nutritional value or the low space requirement, can be utilised optimally.

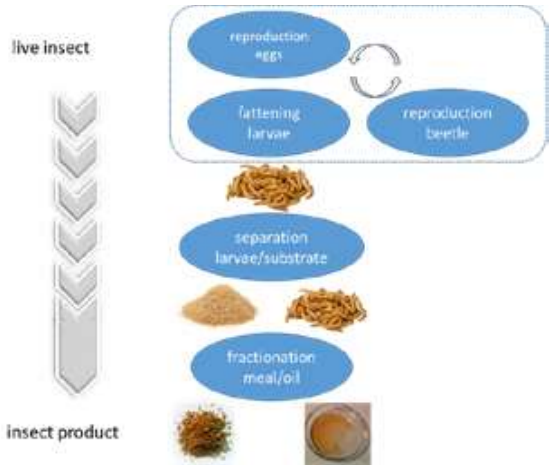

Figure 5: Illustration of possible process steps for fattening mealworms.

Another advantage of insects is their low substrate specificity, the larvae can utilise many raw materials as substrate for growing. In this context, one can turn a disadvantage into an advantage.

With reference to the food industry, it is criticised that in the production of food approximately one third of the food ends up in waste on its way from the farmer to the consumer. Along this chain, about 11 million tons of food waste per year are generated in Germany alone by industry, trade, large-scale consumers and private households[6].

Insects could make efficient use of this resource, since they utilise, among other things, side streams from the food industry as feed. Insect products could then be a low-cost alternative to fish meal and soybean protein, making them attractive to the feed industry and investors. For this to happen, the following conditions, among others, must be met.

- Appropriate studies regarding nutrient transformation on

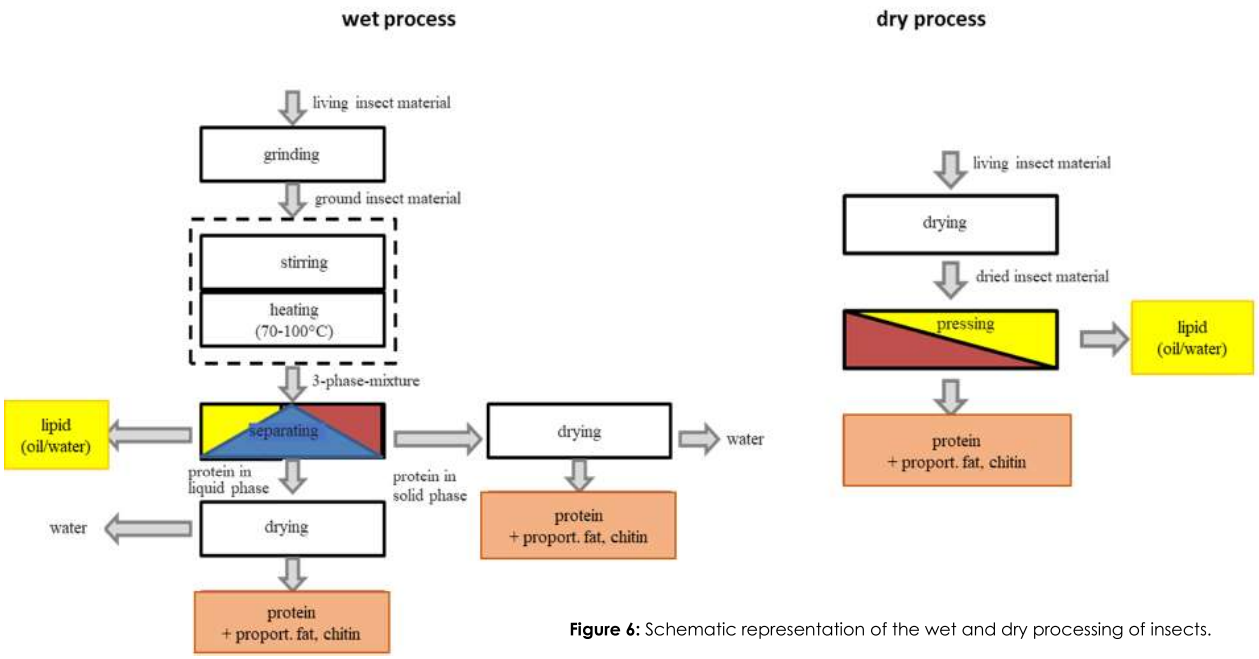

Figure 6: Schematic representation of the wet and dry processing of insects.

yield and product quality must be available.
- Process steps along the production chain should be known and optimised.
- The hygienic status and quality of the corresponding insect products along the value chain must be guaranteed.

In the project "Effects of farm management and processing technology on the hygienic status and product quality of soldier fly larvae (BSFL) and the products produced from them" funded by the Federal

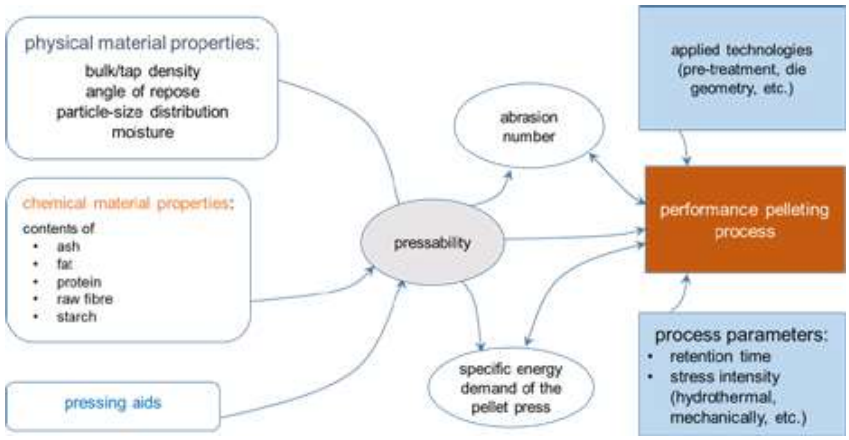

Figure 7: Factors influencing the pelleting process.

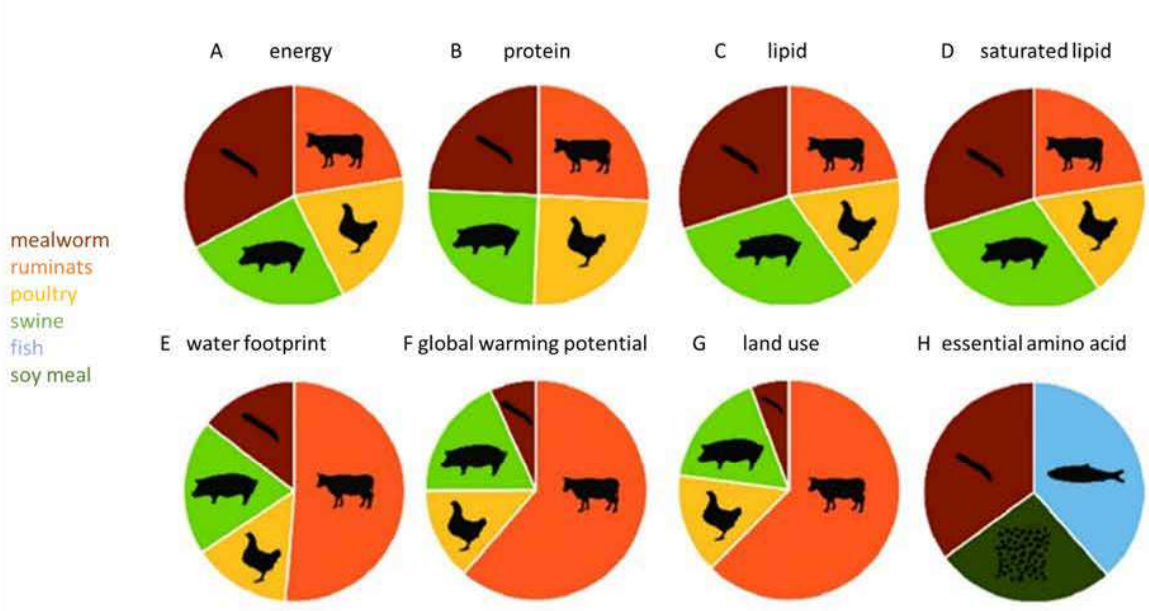

Figure 8: Nutritional values and sustainability of mealworms and conventional food and feed. (A-D) Nutritional value of 100g mealworms compared to livestock. (E-G) Water footprint per edible ton, global warming potential and land use for each 1kg edible part. (H) Essential amino acids of mealworms, soy and fish meal[5]

Ministry for Economic Affairs and Energy via The German Federation of Industrial Research Associations (AiF), these issues are being investigated by the Research Institute of Feed Technology (IFF) and the German Institute of Food Technologies (DIL).

Many dependencies and influencing parameters

Along the process chain (Figure 3) from larvae rearing to protein meal, many dependencies and influencing parameters were pointed out. In order to economically guarantee a balanced and defined composition of insects on an industrial level, both in terms of the fat-protein ratio and the amino acids relevant for livestock farming, monitoring and control of the feeding of the larvae as well as a corresponding degree of automation are essential.

In addition, continuous quality control of raw materials and processes is essential in the production of food and feed, as manufacturers are legally obliged to market only safe products. There is also a need for research on these points.

In an industrial collective research project funded by the Federal Ministry for Economic Affairs and Energy via the AiF, the three research institutes IFF Research Institute of Feed Technology, Bremerhaven University of Applied Sciences and the University of Erlangen-Nuremberg are collaborating in this respect to investigate the optimisation of the processing of mealworm beetle larvae (Tenebrio molitor) and resulting products by automated process control based on a non-invasive near-infrared measuring system.

In order to contribute to more awareness and to advance research, the IFF is offering another application-oriented seminar in October.

Table 1: The percentage of mealworm meal in relation to the soybean extraction meal to be replaced in a pig feed formulation with effect on pellet quality (abrasion according to Pfost, hardness) and soybean oil to be added at constant fat content.

Insect meal content [%]	0	25	50	75
Soy oil [%]	4.75	3.6	2.6	2
Hardness [N]	47	51	63	77
Abrasion [%]	2.5	2.3	1.7	1.5

Please follow and join them at the online conference “Insect revolution! Healthy, sustainable, protein rich and delicious” on October 13-14, 2021.

References

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