FEED DESIGN LAB
HUNGRY FOR KNOWLEDGE



PROJECT PLAN

INCREASING THE KNOWLEDGE OF BLACK SOLDIER FLY LARVAE: GROWING ON DIFFERENT SUBSTRATES AND PROCESSING

AGEETH VAN DER LEE

Project plan

INCREASING THE KNOWLEDGE OF BLACK SOLDIER FLY LARVAE: GROWING ON DIFFERENT SUBSTRATES AND PROCESSING

Joint project of Feed Design Lab partners, executed by:

Feed Design Lab, Wanssum

Wanssum, October 12, 2022

Table of contents

1. Introduction

Feed Design Lab (FDL), located in Wanssum, is the research and education center for innovation and sustainability in the animal feed sector. FDL is active in applied research, the pilot plant is used for experiments for companies and offers practical training courses for employees of the compound feed industry. FDL spends their time on development and executing innovative projects. The end goal is to achieve a 100% circular animal feed with a sustainable (animal) protein chain. With more than 120 partner companies, FDL initiates new projects.

The growing demand for food for humans is putting pressure on the use of, among other things, soy meal in animal feed. That is why research is being conducted into whether alternative (protein) sources are suitable as a replacement. Algae an insects are examples. Algae are a source of proteins and fats, and they have a positive effect on animal health. This allows them, in the future, to be used as a replacement source for proteins in animal feeds. In addition, they contain beneficial fatty acids for human nutrition. Within the INTERREG IDEA project, a test was carried out with dogs in which a small percentage of algae added to the extruded food showed a positive influence on the immune status.

Insects are another solution, because insects can optimally convert their feed, residual material or manure to animal protein (Alternatieve eiwitbronnen, sd).

However, a lot is still unknow in the BSFL sector. A full switch from traditional feed to BSFL leads to reduced performance in livestock. This reduced performance is caused by factors such as high fat content (7-39% DM), ash (9-28% DM), and consequences of processing. Further research is needed on nutrient composition, digestibility and availability for livestock, and on improved methods to process larvae (Barragan-Fonseca, Dicke, & van Loon, Nutritional value of the black soldier fly (Hermetia illucens L.) and its suitability as animal feed - a review, 2017).

Research into the usefulness of insects is being conducted by Feed Design Lab. As described, the aim is to achieve 100% circular animal feed for a sustainable (animal) protein chain. Feed Design Lab carried out projects by students since 2015 to gather more knowledge for all partners of FDL about the feasibility of using insects. Now that the admission of BSFL has been legally regulated for pigs and poultry in addition to pet food and fish feed, there is a growing need to increase knowledge in order to further develop the insect chain. The prices of BSFL are currently still high compared to other protein sources. But after scaling up, further broadening the legislation for raw materials as feed for the BSFL, and awareness amount consumers about the circular economy benefits, the insect sector Is expected to have great potential.

With this project Feed Design Lab wants to demonstrate the possibilities in two parts of the insect chain and to interest partner companies in new possibilities. In the Workshop for partners of Feed Design Lab, held in March 2022, most companies were interested in the part on growing of BSFL and the part of processing after harvesting the BSFL. Using the products from that phase in a dog experiment will be performed in a separate project.

The knowledge from this project is directly applicable for partners. That is why agreements are made about hearing of knowledge and partners will jointly share the costs.

1.1 Insects

Insects have an essential amino acid profile that corresponds with that of pigs or broilers. On average they contain high levels of lysine, threonine and methionine. For pigs and chicken these are the most important (limiting) essential amino acids (Makkar, Tran, Heuzé, & Ankers, 2014). Insects have high levels of energy, proteins and micronutrients. A number of insects can grow on organic waste streams, which ensures a favorable feed conversion because they are cold blooded animals (Spranghers, et al., 2016).

The Black Soldier Fly Larva (BSFL) is a high-grade food source, it is a rich source of proteins and fats. The BSFL contain 40-44% crude protein, the levels of fat varied depending on the diet. Research showed fat levels of 15-25% for larvae on poultry litter, 28% on pig manure, 35% on cattle manure and 42-49% on oil-rich food residues. The dry matter levels of BSFL is quite high, $\pm$ 26% of the total bodyweight (van der Fels-Klerx, Camenzuli , van der Lee, & Oonincx, Uptake of Cadmium, Lead and Arsenic by Tenebrio molitor and Hermetia illucens from Contaminated Substrates, 2016). What makes it easier and less expensive to dry them, in comparison with different fresh co-products (Makkar, Tran, Heuzé, & Ankers, 2014).

Live insects have been allowed to be fed to poultry for some time. The use of dried insects like BSFL is new for livestock but was previously authorized for petfood and fish.

1.2 Goal

To reach the goal of a 100% circular animal feed for a sustainable (animal) protein chain, research is being conducted into the processing of insects in animal feed. The goal of this project is to increase knowledge about the insect sector among partners, resulting in an acceleration of the development of the insect sector. The project is presented to FDL partners, giving them the opportunity for suggestions:

Gain knowledge about different parts in the insect chain.

Two phases:

1. Growing of BSFL with raw materials applicable for BSFL. A substrate with GMP+ raw materials and a substrate with non GMP+ raw materials will be compared.
2. The harvested product will be used to test different ways of blanching, air drying and microwave drying.

2. Material and method

There are two phases in this project:

1. Production of a batches of BSFL used for the project. The substrate (feed) for BSFL may contain raw materials that are GMP+ (information from the end products can later be used for a project with pigs and/or chickens) or raw materials that have the potential as a substrate but are not (yet) GMP+ certified. The production of the BSFL takes place at The Insect School.
2. The produced BSFL are killed after harvest by blanching. One part is dried by microwave method. The other part will be air dried.

2.1 Phase 1: BSFL growing and substrates

In the first phase of this project the following subjects are discussed:

BSFL products which are used for pig or poultry feeds need to be fed with raw materials certified by GMP+. For petfood and aqua feed this not obliged but may be asked for by buying companies.
Using semi-moist raw materials is for the substrate of BSFL interesting: the combination of raw materials in the total composition of the substrate is often made from dry raw materials mixed with water to gain the optimal moisture level for the larvae. When semi-moist raw materials can be used, the price of the substrate can be decreased. Many semi-moist co-products from the food industry are already in use for pigs, poultry or ruminants and are GMP+ certified.
Some co-products are still not used for animals, because the availability is non-continuously, quality is changing often, shelf life is short, nutrients are not usable for the species, and many other reasons. For BSFL these raw materials may be interesting!

2.1.1 Substrate

The larvae will be grown on two different compositions of substrates. One with the use of GMP+ materials and one with the use of other materials. BSFL can grow well on different types of raw materials. This gives the opportunity to test new products in the substrate. However, it is important that the nutrient levels of both substrates are the same. In the first substrate, GMP+ raw materials will be used, because these are already permitted to be used as food. For the second substrate, the raw materials have yet to be determined. It is possible that a component such as dairy will be used as one of the raw materials.
At the beginning of the cultivation, a sample is taken from the substrate, after the larvae have grown another sample is taken. From this, by means of the Weende Analysis, it can be tested which nutrients the larvae have absorbed from the substrate.
The trial feeds will be analyzed for:

- Weende components according to the method prescribed by CVB.
  The Weende analysis is a collective name for analyzes that are applied in animal feed, the following analyzes can be performed: moisture (dry matter), crude fat, crude protein, crude ash and crude fiber. Together with the starch content, these are necessary to determine the nutritional value of the feeds.
- Minerals

2.1.2 Breeding

The first part of raising the BSLF is breeding. The Insect School has a climate-controlled breeding room. In this room, the following parts take place: the production of adult flies, the laying of eggs, and the first development of the young larvae (Figure 1). These eggs are placed above chicken feed substrate. This chicken feed is supplied by Nijssen company. When the eggs hatch, they fall into the container with the substrate. For the first five days, the larvae remain in the breeding room before being moved to the next room.

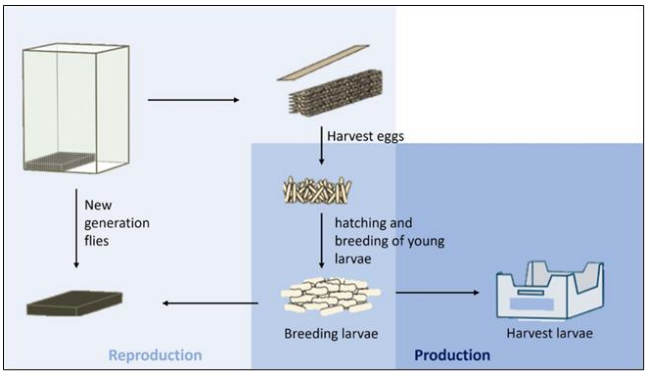

Figure 1. The stages of breeding BSFL.

2.1.3 Production

When the larvae are five days old, they are moved to the production room. In this room, the temperature is constant at 27 degrees Celsius, and the optimal humidity is around 70%. The larvae are brought here from trays to the racks in which the substrate is located. The larvae are then distributed evenly between the two racks. A rack with the substrate with GMP+ materials and a rack without the GMP+ materials in the substrate. In this phase, a risk estimate of 10% will be used.

2.1.4 Process

In the last process, when the larvae are fourteen days old, they are first separated from the substrate. This is done in a non-air-conditioned room. The larvae are separated by a three or four-mm sieve. When the larvae are separated from the substrate, there remain a part larva and a part frass. The larvae are then blanched. This is done in warm water between 70 and 80 degrees Celsius for two minutes. The larvae are than dead, and they can be processed further. After blanching, the larvae contain 65-70% of water. This study does not look at the proportion of mortality during cultivation.
BSFL will be analyzed after blanching and after drying (only the most promising batches).
The BSFL will be analyzed for:

- Weende components according to the method prescribed by CVB.
  Moisture (dry matter), crude fat, crude protein, crude ash and crude fiber, minerals.
- Lysine, reactive lysine, to measure the effect of drying on the available lysine for animals in feeds is an option.

2.2 Phase 2: Drying Process of BSFL

In the second phase the products from phase 1 will be used (Figure 2).

Two methods of drying will be used:

- Air drying with a batch fluid bed dryer at Ventilex.
- Magneton drying at MEAM.

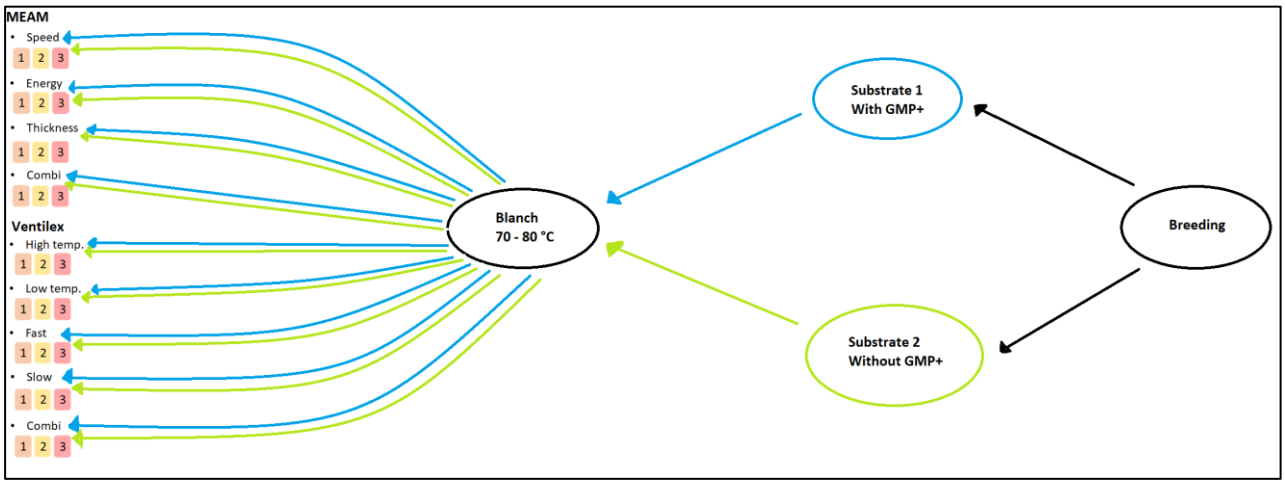

Figure 2. Process diagram.

At the company Ventilex, four treatments will be carried out with the possibility to perform another test with a combination of two parameters. These will then be the optimal parameters, where the most result is obtained. With each treatment, three repetitions are performed. These tests are also carried out twice, once with the larvae on substrate 1 and once with the larvae on substrate 2. This results in thirty tests at Ventilex. The treatments that will be carried out are:

1. Low drying temperature;
2. High Drying temperature;
3. Long drying time;
4. Short drying time.

The treatments are carried out with five kilograms of product.

At the company MEAM, three treatments will be carried out with the possibility to perform another test with a combination of two parameters. These will then be the optimal parameters, where the most result is obtained. With each treatment, three repetitions are performed. These tests are also carried out twice, once with the larvae on substrate 1 and once with the larvae on substrate 2. This results in twenty-four tests at MEAM. The treatments that will be carried out are:

1. Speed of the drying;
2. Energy (temperature);
3. Thickness of the layer of larvae.

The treatments are carried out with five kilograms of product.

The results of all these phases are processed in a report.

3. Time and phase schedule

This project is tentatively scheduled with the goal of finishing next year, see table 2.

Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dec	Jan	Feb
Activity													
Draft project plan													
Partners form projectgroup													
Literature research													
Work out project plan													
Time and phase schedule													
Phase 1: Production BSFL													
Phase 2: Drying test													
Report													
Presentation partners													

Table 2. Time and phase schedule

4. Communication

In the workshop/meeting of March 1, a number of interested partners and suppliers indicated which phases of the project are desirable. This draft pilot plan will be sent to all partners of FDL so that all partners are given the opportunity to participate. Suppliers of products are approached. They can belong to the project group if they are partner. As a sole supplier this is possible under equal project conditions.

During this project Ageeth van der Lee is the project coordinator, who implements the plan established by the project group of partners. Contact details are shown below:

Naam	**E-mailadres**	**telefoon**
Ageeth van der Lee	ageethvanderlee@feeddesignlab.nl	+31 (0)6 30 43 67 43

Communication in the project group is coordinated by FDL. The table below shows the not yet final communication moments of the project:

		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Project plan	Draft project plan													
	Presentation partners													
	Final research plan													
Project group	Partners decide on participation													
Carry out research	Phase 1													
	Phase 2													
Project report	Presentation partners draft report													
	Delivery final report													

Table 3. Communication moments.

The information and data in this project are intended for project members only.
Confidentially: partners decide about an agreement.

5. Investment

Partners of Feed Design Lab have the possibility to participate and receive exclusive the information and research report of this project.
The investment will be divided by the number of partners that participate in this project.

The provisional budget is € 42.000. The distribution between the costs of substrate, test facilities, analyses and working hours of project support and research report are indicated in the table below.

	company	€
Project leading	FDL	2.000
Substrate 1	partner?	2.000
Substrate 2	partner?	2.000
Production room (10 days)	Insect School	3.060
Gas + electricity	Insect School	750
Eggs		1.000
Drying	MEAM, Ventilex	20.000
Analyses	partner?	1500
Materials and transport		1.000
Statistics	partner?	1.000
Reporting	FDL	4.000
Final project meeting	FDL	1.500
Unforseen		2.190
Total		42.000

Table 4 Draft budget

For example, with 10 participants, the investment per project participant is €4.200 excl. VAT.

6. Bibliography

Alternatieve eiwitbronnen. (sd). Opgehaald van Coppens diervoeding: https://www.coppens.nl/coppens/innovaties/alternatieve-eiwitbronnen

Barragan-Fonseca, K., Dicke, M. & Van Loon, J. (2017). Nutritional value of the black soldier fly (Hermetia illucens L.) and its suitability as animal feed – a review. Journal of Insects as Food and Feed 3(2), 105-120.

Spranghers, T., Ottoboni, M., Klootwijk, C., Ovyn, A., Deboosere, S., De Meulenaer, B., . . . De Smet, S. (2016). *Nutritional composition of black soldier fly (Hermetia illucens) prepupae reared on different organic waste substrates.* Wiley Online Library.

van der Fels-Klerx, H., Camenzuli, L., van der Lee, M., & Oonincx, D. (2016). *Uptake of Cadmium, Lead and Arsenic by Tenebrio molitor and Hermetia illucens from Contaminated Substrates.* Texas: The University of Texas. Retrieved from https://www.researchgate.net/publication/310429878_Uptake_of_Cadmium_Lead_and_Arsenic_by_Tenebrio_molitor_and_Hermetia_illucens_from_Contaminated_Substrates