Our research – your profit

Hermetia as a transformer of organic waste streams for aquaculture feed

Smárason, B.Ö[1,4]., Knobloch, S [1]., Björnsdóttir, R[1,3]., Davíðsdóttir, B[2]., Oddsson, S[5]., Bergsson, A.B[1].,Margeirsson, S[1]., Árnason, J[1].

Introduction

This study seeks to answer questions related to optimal raw material composition for the Black soldier fly larvae as ingredient for fish feed. With regards to resource availability, utilisation and environmental impacts it is important to look at untraditional biological streams as raw material sources for fish feed. One way is to transform biomaterial through insects such as the Black soldier fly *(Hermetia illucens)* (BSF), which is a common fly of the family Stratiomyidae. Due to the properties of its detritivorous larvae as well as it's relatively simple cultivation the BSF has recently gained widespread popularity as food waste converter, for decontamination purposes and as food for animals and humans alike.

Significant amounts of raw materials are underutilized in Iceland, including wastes from agriculture, fish processing, households and manure from livestock production. Due to low protein content, these waste streams are not suitable for direct use in fish feed but can be utilized for the cultivation of invertebrates, which in turn transform them into high quality protein and oil ingredients for feed. In addition, this would reduce the enormous amount of waste generated, making the benefits of their use substantial in relation to resource utilization and environmental impacts.

Goals of the study

- **Test the effects of different biomaterial composition on growth and feed utilisation of BSF larvae**
- **Analyse the effects of substrate on larvae content**
- **Develop sustainable fish feed based on BSF larvae**
- **Increase co/by-product utilisation**
- **Reduce waste**

Materials and Methods

Figure 1. BSF cage in the culture room

The culture room contains the fly cage, two air humidifiers, the heating element, an outdoor air exchange, halogen light with timer, culture buckets, a pump sprayer and further equipment. The fly cage can be opened and closed from the front side with the intended zipper. Culture buckets have a lid with air holes or a larger hole covered with fine mesh to allow an air flow while preventing escapes.

Figure 2. Corrugated cardboard with BSF egg deposits

Figure 3. Culture bucket bustling with hungry larvae

Figure 4. Feed experiment

Feeding trials

Two experiments with different biomaterial substrates have been conducted to measure the impact of substrate on growth rates and feed utilisation. Both experiments lasted 14 days with chicken feed used as control feed. Nine buckets, each containing 2,03 grams of larvae and each feed was tested in 3 buckets. The larvae were fed ad libitum. Fresh, minced tomatoes and apples were selected for the first trial and mixed lunch waste from Matís cafeteria for the second trial, containing either high amount of vegetables or mixed lunch with meat (Table 1).

- Culture room was built to keep controlled conditions (pre-pupae usually emerge after 2-4 weeks under optimal temperature, humidity and feed supply [1]).
- Temperature was kept between 26 and 37˚C.
- Relative humidity was 50-90 %.

Table 1. Substrate composition in trials 1 and 2.

		Trial 1		Trial 2	
Feed composition % in dry matter	**Chicken feed (control)**	**Tomatoes, fresh**	**Apples, fresh**	**Veg lunch**	**Mixed lunch**
Crude Protein (CP)	24,3	11,1	1,9	12,8	14,4
Crude Lipid (CP)	4,1	13	2,5	23,0	8,0
Ash	6,3	9,3	1,2	4,9	3,4
Nitrogen-free Extract (NFE)	65,3	66,7	94,4	59,3	74,1

Contact: Birgir Örn Smárason (birgir.o.smarason@matis.is

[1] Matís ltd - Icelandic food & biotech R&D, Vínlandsleið 12, 113 Reykjavík, Iceland

[2] Faculty of Economics and faculty of Environment and Life Sciences, University of Iceland, Gimli, Sæmundargötu 2, 101 Reykjavík, Iceland

[3] Natural Resources Sciences, University of Akureyri, Borgir v/Norðurslóðum, 600 Akureyri, Iceland

[4] Faculty of Environment and Life Sciences, University of Iceland, Gimli, Sæmundargötu 2, 101 Reykjavík, Iceland

[5] Matorka – Sustainable Food, Hlíðarsmári 6, 201 Kópavogur, Iceland

Results

Results so far have shown that the larvae can be grown on different substrates but with variable efficiency.

Trial 1 - Apples, Tomatoes

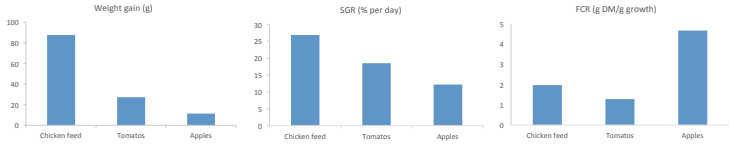

Figure 5. Weight gain, specific growth rate (SGR) and feed conversion ratio (FCR) in trial 1.

The results from the first trial (Figure 5) showed that the increase in biomass was highest in larvae offered chicken feed, and lowest in larvae offered fresh apples, according to initial- and final weight and specific growth rate (SGR). Calculated feed conversion ratio (FCR) from given dry matter was highest in larvae offered apples but lowest in those offered tomatoes.

Trial 2 - Veggie lunch, Mixed lunch

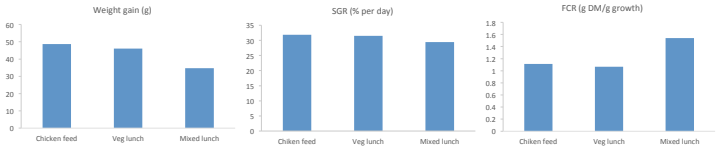

Figure 6. Weight gain, specific growth rate (SGR) and feed conversion ratio (FCR) i trial 2.

The results from the second (Figure 6) trial showed that the increase in biomass was highest in larva offered chicken feed and lowest in larvae offered mixed lunch. SGR was similar between all groups, but FCR was highest with mixed lunch and lowest with veg lunch.

Larvae composition

The results from the trials show that there is a tendency that composition of the substrate/feed (see Table 1) has an effect on the composition of the larvae (see Table 2) and thereby on their nutritive value.

Table 2. Dry matter composition of larvae from trial 1 and 2.

		Trial 1		Trial 2	
Larvae dry matter composition	**Chiken feed (control)**	**Tomatoes, fresh**	**Apples, fresh**	**Veg lunch**	**Mixed lunch**
Crude Protein (CP)	43,3	39,2	20,2	28,4	24,7
Crude Lipid (CP)	16,8	38,6	66,9	53,5	31,2
Ash	9,0	3,6	2,1	4,1	3,4
Nitrogen-free Extract (NFE)	23,1	18,7	10,7	26,7	22,4

Carbon Footprint

Carbon footprint of BSF meal and Fishmeal was assessed using the Life Cycle Assessment methodology. Analysis of larvae offered fresh tomatoes revealed up to 44% less CO_2 emission (Figure 7) .

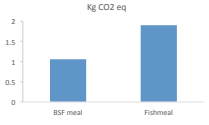

Figure 7. Carbon footprint from the production of 1 kg of BSF meal and 1 kg of Fishmeal [2].

Conclusions

- Growth (Weight gain; SGR) was found to be variable but much higher than known in fish.
- Feed utilisation was also variable, with best results comparable to fish.
- Nutrient composition of larvae seems to vary with different feed composition.
- Carbon footprint in aquaculture can be lowered significantly by replacing fishmeal with BSF meal.
- Black soldier fly larvae appear to be very interesting raw material for fish diets.

References

[1] Diener, S. et al., 2011. Black soldier larvae for organic waste treatment prospects and constraints. Khulna, M Alamgir, QH Bari, IM Rafizul, SMT Islam, G Sarkar & MK Howlander (Eds.), pp. 1-8.

[2] Smárason, B. Ö. 2013. Aquaculture and the Environment. Life cycle assessment on Icelandic Arctic char fed with three different feed types. Unpublished MS thesis. Faculty of Life and Environmental Sciences. University of Iceland.