Fact Sheet – Insects for Fish Feed

What is the product?

Consumption of fish and seafood in Australia has doubled in the last 10 years and currently stands at around 13kg per person anually. This has been predicted to increase to 17kg by 2020 and 25kg per year by 2050, giving a total domestic requirement of 1.15kt annually. Given falling wild catches, aquaculture needs to double by 2020 and double again by 2050 to meet this demand.

One factor restricting increased aquaculture is the reliance on wild-caught fish as feedstock. This is not sustainable in the long term, and has led to a search for alternative sources of high protein, high fat food sources. These have included cottonseed meal, legume crops such as lupins and soy, meat and bone meal and poultry wastes.

Plant-based fish food have problems with poor palatability, presence of anti-nutrients (e.g. phytic acid), intolerance to complex carbohydrates and deficiencies in essential amino acids. Animal-based foods are better but also have problems such as poor consumer acceptance, high levels of saturated fats, absence of omega 3 fatty acids and issues with food safety from rendered animal meal.

Insect-based protein meals offer an alternative to plant- and animal-based fish food as ingredients in fish food for aquaculture.

The main species studied are:

- Yellow mealworm (*Tenebrio molitor*)
- Black soldier fly (*Hermetia illucens*)
- The super worm (*Zophobas morio*)

These insects reproduce rapidly. For example, a black soldier fly lays around 900 eggs during her adult life of only 5-8 days. The eggs take around 4-5 days to hatch and 2-3 weeks to mature. At this point they leave the food material to pupate, making them easy to collect.

Insects are also efficient converters of food to body mass; 2.2kg of dried carrots produced around 1kg of mealworms, while 5kg fresh pumpkin produced 1 kg of black soldier fly. This is similar to chickens (1 kg from 2.3kg dry feed).

Mealworms are around 28% high quality protein (59% after drying) and 12.5% fat when harvested as mature larvae. Mature soldier fly larvae are approximately 44% dry matter, of which up to 42% is protein and 35% fat. After harvest, insect larvae can be dried and milled, producing high protein 'flour' that can be readily made into other products.

What is the benefit to vegetable growers?

All of these species of insects can be raised partly or wholly on vegetable feedstocks.

There has already been considerable interest in using insects in poultry food. Chickens, especially laying hens and meat birds, require protein levels of 15 – 20% to optimize productivity. Although insects are ideal, chicken feed is relatively low value, retailing in the order of $200-$400/t as a bulk supply.

In contrast, basic dried fishmeal costs approx. $900-$1,500/t. There appears to be general agreement that insects would be a suitable ingredient in fish feeds. Their high dry matter and range of amino acids mean they are suitable for a range of species.

For example, one study showed that up to 50% of fishmeal could be replaced with yellow mealworm meal without affecting fish growth. Up to 33% of the protein requirements of turbot could be met using black soldier flies produced commercially from greenhouse wastes without affecting fish quality, while rainbow trout partially fed on enriched black soldier fly larvae had the same growth rates and flavour as those fed only on fishmeal.

Yellow mealworm — Source: ptcjipajki.com | *Black soldier fly* — Source: blacksoldierflyblog.com | *Superworm* — Source: ptcjipajki.com

Aquaponics

Using vegetable wastes to feed insects, which can then be turned into fish feed, raises the possibility of a circular production system.

Fish waste from aquaculture can be used in "aquaponics", hydroponic solutions that can then be used to grow vegetables. Such systems are inherently efficient and can be used to produce both fish and vegetables close to urban areas. For example, in NSW there is a 0.8 ha commercial pilot system in operation at Camden operated jointly by Urban Ecological Systems and the University of Sydney, as well as a combined barramundi / hydroponic lettuce farm at Port Stephens.

Materials, equipment and research required

While there are production systems in place for black soldier fly, mealworms and superworms, these have not been focussed on using vegetable wastes. In the case of black soldier fly, the emphasis has been on utilising general organic wastes and turning these into compost. Mealworms are mainly fed on grains, but the insects can also happily eat vegetables.

While it has been shown that potato is suitable for black soldier fly larvae and mealworms can be raised on carrots, there is little information on the quantities and quality of materials required, or the effects on insect growth rate, protein content or suitability for meal.

A number of technical issues need to be overcome in terms of genetic replenishment and ensuring a high level of mating and egg production by mature insects, as well as maintaining a disease-free environment.

"Biopod" for semi commercial black soldier fly rearing

In general, equipment required is not complex. A 1.35m diameter "biopod" for black soldier fly culture is commercially available for approx $200. This can use 40kg waste vegetables daily.

The biopod consists of a plastic tub with "ramps" up the side leading to a hole. Once mature and ready to pupate, larvae naturally climb the ramps and drop through the hole into a collection bucket below.

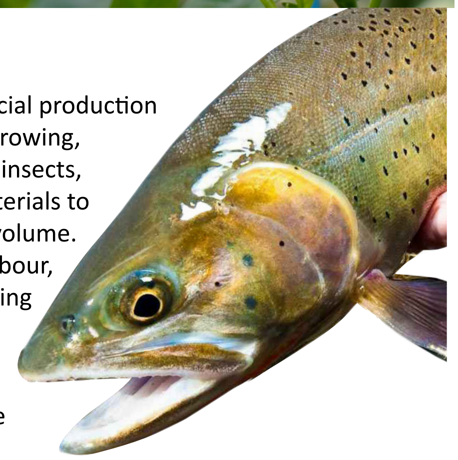
There are opportunities for the vegetable industry to link with existing projects developing black soldier fly larvae for commercial fish feed.

Liquids draining from the base of the tub can be absorbed onto organic materials, making a high nitrogen compost.

The UES facility at Camden plans to develop the use of Black Soldier Fly larvae as a source of fish food made from vegetable waste. This project will involve the University of Sydney Veterinary Science and Agriculture faculties.

This represents an excellent opportunity for the vegetable industry to take part in the development and commercialisation of fish feed produced from vegetable waste by black soldier fly larvae.

Economic viability



The main factor limiting commercial production of insects has been the costs of growing, collecting, drying and milling the insects, and the lack of sufficient raw materials to produce an economically viable volume. Production requires significant labour, while the costs of drying and milling could be $150-400/t.

However, commercial production of insects is now a reality in some parts of the world. For example:

- AgriProtein in South Africa is mass-producing 24 t dry house fly larvae per month for fish feed production. The larvae are fed on vegetable wastes with added abattoir blood.
- Organis Nutrition, USA has constructed an integrated pilot production facility for black soldier fly, technology that it plans to extend into larger facilities globally.
- Another USA-based company, Enviroflight, is also developing mass-reared black soldier fly for use in fish feeds.
- Kreca farm in the Netherlands produces 14 species of insects for animal food as well as 3 species (mealworm, superworm and locust) for human consumption.
- HaoCheng mealworm farm in China produces 50 t mealworm and superworm per month for animal food.

Mealworms and soldier fly larvae are 55-60% water, so 2.2-2.5t live insects would be needed to produce a 1t of dried material.

Feed sources are generally sold on the basis of their protein content. Dried and milled larvae with a protein content of close to 60%, would be expected to be worth approx. $700/t. If protein levels were close to 40% then the larvae would be worth closer to $400/t. However, it is noted that HaoCheng farm sells dried mealworms for US$6,400/t and dried superworm for US$10,500/t.

Although initial calculations suggest that prices would have to be at least $2,000/t for insect production to be viable, there are still too many unknowns to determine whether this is possible or realistic. This appears to be an area worthy of further investigation.

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