Potential Scope of Use

Conservative estimates indicate that there are about 1,900 species of edible insects worldwide, including various species of cricket, dragonfly, scorpion, cockroach, beetle, spider, cicada, bamboo and silk worm, water bug, grasshopper, ant, fly larvae, and various other insect larvae. These little creatures are a natural food source for many animals, including humans, supplying large amounts of protein (7-48 percent), fat (1-36 percent), energy (890-4,900 kcal/kg) on a fresh weight basis, and essential minerals and vitamins. Furthermore, many insects require little or no preparation or processing prior to consumption. Since prehistoric times, entomophagy – insect consumption – has served as a vital source of nutrition for human populations in the Americas, Africa, Asia, Australia and New Zealand. Regrettably some cultures have lost their taste for insects, developing taboos, not only for direct consumption but also for feeding animals with insects and insect products.

Production of insects has a few advantages over traditional agricultural crops, such as small footprint needed to produce a relatively high amount of protein and fats, a balanced amino acid composition, and health-promoting molecules such as anti-oxidants, vitamins, minerals, polysaccharides, nucleotides and nucleosides. Also, many insects are herbivores or omnivores and can consume plant material, agricultural wastes, and even restaurant waste that usually ends up in landfills. This food flexibility means that many insects have the capability to recycle organic wastes.

Use in Aquafeeds

Currently most marine feed ingredients (e.g. fishmeal) in aquafeeds are being replaced by plant-based ingredients. Plant-based ingredients are readily available and a good source of protein and carbohydrates; however, the loss of beneficial compounds (vitamins, antioxidants and minerals) can occur during processing of plant-based ingredients. In addition, plant-based ingredients often contain (CONTINUED ON PAGE 62)
undesirable carbohydrates and anti-nutritional factors, such as trypsin inhibitors, saponins and phytate, have unbalanced amino acid profiles, and lack taurine and cholesterol. These negative qualities of plant-based ingredients give insect meals certain advantages but insect ingredients are not free of flaws either because they have certain compounds that can limit their inclusion levels in diets, such as chitin, a structural carbohydrate of insect exoskeleton. In addition, some insect meals contain high amounts of fat.

For more than a decade, several companies have been producing insects for animal feed and human consumption in North America, Asia, Africa, and Europe. Researchers have conducted numerous studies on the utilization of insects as feed ingredients for aquaculture, poultry, swine, and other species worldwide. Although there are a few insect producers in the U.S., the U.S. Food and Drug Administration is still debating the regulation of insect protein in animal diets. In contrast, the European Union has been proactive, recently authorizing the use of insect ingredients in aquafeeds, and plan to authorize insects as an approved ingredient in poultry feed by 2020. It is anticipated that this significant achievement for the insect producing industry will stimulate growth and reduce production costs of insect ingredients for both the aquaculture and poultry industries in Europe going forward.

**Black Soldier Fly Meal in Aquafeeds**

Black soldier fly *Hermetia illucens* is an insect with a short life cycle of about one month and that is easy to culture. Black soldier fly larvae (BF) are very efficient composters, rapidly consuming agricultural and food waste, accruing protein (44 percent), fat (36 percent), anti-oxidants, vitamins and minerals in its body, and returning vital nutrients to the soil and environment.

Oceanic Institute of Hawai`i Pacific University (OI), in a collaboration with Prota Culture LLC, and with financial support from USDA’s Center for Tropical and Subtropical Aquaculture (CTSA), has made important progress in evaluating the potential use of black soldier fly larvae meal (BFm) in aquaculture diets. Trials to reduce fat content and assess shelf life of BF under various environmental conditions have been conducted with promising results. The quality of protein-rich BFm after six months of storage at room temperature remained high, indicating excellent stability. The BFm has a nearly 1:1 ratio of essential and non-essential amino acids, including good levels of the limiting amino acids lysine (2.1 percent), methionine (0.7 percent), and histidine (1.1 percent). These results are not statistically different
from the freshly produced BFm, demonstrating the ingredient’s stability, maintaining optimal nutritional characteristics, quality and safety to be fed to animals for a long period of time.

With regard to fatty acid composition, BFm lacks omega-3 highly unsaturated fatty acids (HUFA) that are found in most marine algae and fish. Nearly 70 percent of total fatty acids are saturated fatty acids and 25 percent are monounsaturated or polyunsaturated fatty acids. An ingredient with 36 percent crude fat that lacks omega-3 HUFAs is not ideal for aquafeeds.

In an effort to reduce fat, both commercial oil press and hexane extraction processing was evaluated with mixed results. The oil press was only capable of reducing fat content by 10 percent, which left about 20 percent fat in the BFm. However, hexane extraction reduced the fat content to 5-8 percent, resulting in a low-fat BFm that is better for aquafeeds. Reduction of the fat content of BFm had an additional positive outcome in that the crude protein content increased to about 53 percent.

**Tilapia and Shrimp Trials**

A preliminary evaluation on the palatability and digestibility of BFm was conducted with tilapia using 30 percent inclusion of BFm in the feed. The BFm diet was compared with a control diet and a commercial tilapia feed and results indicated that the diet was palatable for tilapia. The apparent digestibility of dry matter, crude protein, and gross energy in the BFm diet was not statistically different from the control and commercial diets. In white shrimp Litopenaeus vannamei, a preliminary trial was conducted with a control diet and 15 or 30 percent BFm inclusion and no negative impacts on palatability, feed intake, growth, or survival were detected. A complete feed trial with shrimp will be conducted during 2017.

Black soldier fly larvae meal appears to be a palatable source of good protein, fat, anti-oxidants, vitamins, and minerals for fish and shrimp. If low-fat BFm is required to formulate diets, hexane extraction of excessive fats appears to be an efficient method for extraction. In addition, BFm, when properly stored, has a shelf life of at least six months with no significant nutrient losses. Results from these preliminary trials indicate that BFm has the potential to serve as an aquafeed ingredient, with indications of being a promising ingredient in other livestock feed as well, warranting further research.

**Notes**

Spencer Davis, Kathleen Ramm, Zhi Yong Ju, Fabio Soller*, Aquatic Feeds and Nutrition Department, Oceanic Institute of Hawaii Pacific University, www.oceanicinstitute.org

* Corresponding author fsoller@hpu.edu

**References**


