Beneficial Properties of Insects:

Antimicrobial Peptides, Chitin, and Lauric Acid

Insect based ingredients are becoming widely accepted and utilized in both livestock feeds and pet foods. Insects are highly nutritious, palatable and sustainable. They are intentionally and opportunistically ingested by cats, dogs, poultry, swine, fish and other species including grazing livestock. The three most commonly used insect species as ingredients in animal feed and pet food are crickets (*Acheta domesticus*), larvae of the black soldier fly (*Hermetia illucens*, BSFL), and mealworms (*Tenebrio molitor*). As highlighted by Koutsos et al. (2022), there are numerous studies demonstrating the nutritional efficacy of insect ingredients, many of which have focused on BSFL. Recently, researchers have begun to explore specific properties of BSFL that may provide animal health benefits in addition to nutritional benefits. These properties include antimicrobial peptides (AMPs), chitin, and lauric acid.

Antimicrobial Peptides (AMPs)

Insects display a particularly strong resistance to most infections. One reason for this resistance is the unique insect immune system that is dominated by robust innate immune defenses including antimicrobial peptides (Samakovlis et al., 1990). These peptides may also be referred to as host defense peptides, and are present in many different organisms and ecosystems (Kim et al., 2005). AMPs act by preventing harmful pathogens from infecting the host (Harlystiarini et al., 2019). This efficacy exists against a range of pathogen types including viruses, bacteria, fungi, and parasites (Bahar et al., 2013). There are many different mechanisms by which AMPs may impact microorganisms; however, most AMPs act directly on the pathogen by disrupting the cellular membrane or preventing the cell from replicating. This direct interaction method of antimicrobial activity makes it incredibly difficult for pathogens to develop resistance to AMPs, and in 2014, Bagley et al. proposed the use of AMPs as an alternative to antibiotics in an effort to combat concerns regarding antibiotic resistance.

AMPs have demonstrated a variety of properties that could be beneficial to the animals. Wang et al. (2022) used meta-analysis to demonstrate the ability of AMPs to boost aquatic species health when fed as part of the diet. This was shown in both fresh and saltwater aquatic species. Additionally, AMPs extracted from the gastrointestinal tract of swine have been shown to alleviate growth depression in poultry exposed to heat stress, and increase the populations of beneficial bacteria such as *Lactobacillus* spp in the gut (Hu et al., 2017; Daneshmand et al., 2019). AMPs are also very small molecules, making them more resistant to high temperature protein degradation and conformational changes, making them an excellent candidate for animal feed applications, which are often exposed to high temperatures during extrusion or pelleting (Qiao et al., 2020).

Being an integral part of their robust and unique immune system, AMPs have been identified in a variety of insect species. There are 57 identified genes coding for various AMPs present in BSFL adults and larvae (Vogel et al., 2018; Moretta et al., 2020). This is the highest reported number of AMP genes of any invertebrate (Vogel et al., 2018). Although the abundance of these AMP coding genes in BSFL is clear, the expression of these genes and type of AMPs produced can be modified. BSFL rearing practices such as diet, processing method, and breeding program will impact AMP expression and efficacy against pathogens (Kong et al., 2019). This high level of AMP expression makes BSFL ingredients a beneficial addition to any animal feeding program.

Chitin

Chitin is a highly abundant compound in nature that is a component of insect and crustacean exoskeletons (Kumar et al., 2000). Chitin was previously thought of as an anti-nutritional component of animal diets due to its ability to decrease digestibility when fed at high concentrations. However, as chitin research has developed, the compound is now known to improve disease response by priming the immune system when fed at less than 3% of total diet composition (Elieh et al., 2018). The mechanism behind this priming activity is thought to be multifaceted. First, chitin has the ability to induce a number of adaptive immune pathways in both human and animal species including Th1, Th2, and Th17 pathways (Da Silva et al., 2010). These pathways are critical mediators of gut inflammation and cellular signaling. Additionally, in many species, chitin is not absorbed in the small intestine, allowing it to pass to the large intestine where bacteria can utilize the compound as a fermentation substance (Yu et al., 2019).

Chitin has also proven effective as a prebiotic, promoting increased proliferation of beneficial lactic acid bacteria, and a decreased occurrence of pathogenic bacteria in the gut such as *E. coli* and *Salmonella* spp. (Dörper et al., 2021). Chitin derived from insect species has been shown to improve performance parameters and carcass quality in poultry and reduce post weaning diarrhea in piglets when included in the diet at low levels (Lokman et al., 2019; Xu et al, 2018). Shah et al (2022) concluded that chitin has the potential to improve growth and milk production in dairy cows, and even increased wool production in small ruminants. Feeding chitin at low inclusion rates also enhanced butyrate production in the gut. This volatile fatty acid is speculated to play a critical role in developing healthy microflora in the animal gastrointestinal tract (Khempaka et al., 2011).

Lauric Acid

The third beneficial component of BSFL derived ingredients is lauric acid. Lauric acid is a medium chain fatty acid (MCFA) commonly sourced from coconut and palm oils. Lauric acid is the major component of BSFL lipid fraction, and has shown a wide array of antimicrobial properties (Kumar et al., 2020). It is important to keep in mind that the lauric acid content of BSFL is somewhat diet dependent, with concentrations varying based on the feedstock used in BSFL rearing.

Similar to AMPs, lauric acid and its derivatives have been proposed by Borrelli et al. (2021) as an alternative to antibiotics in order to combat antimicrobial resistance. Generally speaking, lauric acid disrupts the cellular membrane by inducing cell lysis. This is a generalized response, which makes it difficult for bacteria and other pathogens to develop resistance (Jackman et al., 2020). Lauric acid is highly bioavailable, being easily absorbed and transported throughout the body unlike many other fatty acids (Dayrit et al., 2015). This increased viability is because lauric acid does not require any lipolysis before being absorbed by intestinal cells (Greenberger et al., 1965; Guillot et al., 1993). Because of the ease at which lauric acid can be absorbed, Hall et al. (2014) shown as an excellent feed component for geriatric animals, reducing the effects of age on kidney function and other biomarkers .

In animal studies, BSFL oil has demonstrated improved growth performance in newly weaned piglets when compared to a diet containing poultry fat (Van Heugten et al., 2022). In rainbow trout, BSFL oil decreased gut inflammation and improved innate immune response when compared to a soybean-based control diet (Kumar et al., 2021). In poultry, the inclusion of BSFL oil reduced levels of harmful bacteria and decreased the expression of inflammatory markers in the digestive tract (Sypniewski et al., 2020).

Conclusions

Insect-derived ingredients offer a wide range of value-added properties that can benefit animal nutrition and performance. Of the many beneficial compounds found in insect ingredients, AMPs , chitin, and lauric acid are the best characterized and most understood. All three of these compounds have displayed antimicrobial potential, and are at relatively high concentrations in BSFL-derived ingredients when compared to other sources.

AMPs, chitin, and lauric acid have shown beneficial properties when fed to a multitude of animal species. The combination of these three beneficial compounds in BSFL ingredients make it an excellent ingredient choice for animal feeding programs through decreased mortality, inflammation reduction, improved gut microflora, and improved growth performance.

References

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