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Impact of Dietary Macronutrient and Lipid Composition on the Fatty Acid Profile of Black Soldier Fly Larvae

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Abstract

The biological recycling of food waste through black soldier fly larvae (BSFL, *Hermetia illucens*) represents a pivotal strategy for circular agriculture, yet the marketability of insect-based feed ingredients depends heavily on defining their functional characteristics to compete with traditional fats. This study investigated how dietary macronutrient and lipid availability modulate the larval lipidome, testing the hypothesis that while BSFL bioaccumulate specific long-chain fatty acids from fat-rich substrates, they primarily rely on *de novo* biosynthesis to produce medium-chain fatty acids (MCFA) when reared on high-carbohydrate and high-protein streams. Three experimental diets were utilised: a corn-soy control, a protein-rich bread waste-based diet, and a fat-enriched coconut oil-based diet. Larvae were reared from day 7 to 18 (n = 6 per treatment), followed by fatty acid profiling of both diets and larval oils via gas chromatography - flame ionisation detection (GC-FID). The control and bread-based diets contained minimal amounts of fatty acids, whereas the coconut oil-based diet was rich in palmitic, oleic, linoleic, and lauric acids. In the larvae, dominant fatty acids included palmitic and lauric acids. Relative to the total larval fatty acid content, the control, bread-based, and coconut oil-based treatments yielded 11.60, 10.03, and 21.94% palmitic acid ($P < 0.05$) and 24.32, 30.98, and 17.28% lauric acid ($P < 0.05$), respectively. These results demonstrated that larvae reared on the oil-enriched diet exhibited a significant accumulation of palmitic acid, reflecting direct bioaccumulation. In contrast, larvae fed the protein-rich bread waste diet, despite the substrate having low initial lauric acid content, exhibited significantly higher levels of lauric acid compared to the control group. The latter suggests that elevated dietary carbohydrate and protein levels effectively stimulated *de novo* biosynthesis of MCFA, aligning with findings by Spranghers et al. (2017) regarding the plastic nature of larval composition. Furthermore, the larval capacity to modify their profile regardless of substrate extremes ensures a consistent, functional product. By strategically selecting waste streams, producers can engineer BSFL to be rich in lauric acid, which provides documented antimicrobial benefits in livestock (Ewald et al., 2020). Clarifying these functional feed characters is essential for market adoption, as it transforms BSFL from a simple protein substitute into a value-added feed additive. This study reinforces that BSFL-driven upcycling of food waste not only reduces environmental footprints but also allows for the precision design of sustainable, health-promoting animal feed ingredients.

Keywords: Hermetia illucens, insect farming, fatty acids, functional feed, sustainable nutrition