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Hermetia illucens: a new sustainable biotechnology for food waste valorization and animal feed – a study of cellular responses to Hi-diets

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Abstract

The growing population and the increasing global demand for proteins impose the urgent need to find alternative and sustainable nutritional sources to feed the world. Insects represent a promising solution to face the nutritional requirements while reducing food waste and their negative economic, environmental and social impacts. The Black Soldier Fly (BSF) *Hermetia illucens* during the larval stages can efficiently bioconvert a variety of organic substrates into valuable larval biomass with a great nutritional potential in animal feed. In this study, we describe a new BSF-based food waste valorization biotechnology developed in the pilot plant *Progetto Hermetia* (Italy) devoted to insect breeding and reproduction, larval bioconversion and processing of products and by-products. All the outputs of the process, mainly larval and residual biomass, can be used as valuable biomass for insect meal and biocompost production thus making this biotechnology as a zero-waste and sustainable process for “modernizing” biomass use. Results showed that the BSF can efficiently bioconvert food waste producing BSF larvae characterized by relevant biochemical profiles including essential amino acids, fatty acids and minerals that meet the nutritional properties of animal feed for aquaculture. Thereafter, the effects of *Hi*-diets on the growth performance of the model organism zebrafish (*Danio rerio*) by total dietary replacement of fishmeal with defatted BSF meals were investigated. The cellular response of fish to *Hi*-diets was evaluated by quantitative expression analysis (qPCR) of genes involved in several metabolic pathways. *Hi*-diets showed beneficial effects on fish growth performance as assessed by biometric indices (final total and standard length, final body weight, weight gain, daily growth rate, specific growth rate). These positive effects can be imputable to the activation of myogenic regulatory factors (MRFs), as assessed by gene expression analysis, suggesting that the nutrient supply could positively influence the process of skeletal myogenesis. Moreover, the expression of genes related to stress and immune response indicated that diets

containing defatted *Hi*-meals do not impair the wellness of fish. Since zebrafish share similar cellular and physiological pathways with aquaculture species, results from this study could provide useful information about the possible effects of BSF inclusion as feed ingredient in conventional aquafeed. Taken together, the findings from this study showed that *Hi*-meals can totally replace fishmeal with a positive impact on adult zebrafish growth thus suggesting that this new insect-based biotechnology has a great potential in the waste valorization process to obtain high value nutritional resources in a circular economy context.

Keywords: Food waste valorization, bioconversion, novel protein source, Hermetia illucens meal, acquafeed