Morphofunctional adaptation of *Hermetia illucens* larval midgut to rearing substrates with different nutritional quality

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Black soldier fly (*Hermetia illucens*) larvae (BSFL) are increasingly used for waste management purposes because of their extraordinary ability to feed on a variety of waste organic matter and convert this material into valuable products. Although nutrient composition of the rearing substrate can affect larval performances and the bioconversion process, the astonishing adaptability of this insect to dietary substrates, without any dramatic impact on its development, strongly suggests that BSFL can finely and profitably regulate nutrient intake and post-ingestion processes to match their nutritional requirements. In the present study we investigated if and how the midgut of BSFL, which is involved in the digestion and absorption of nutrients, sets in motion post-ingestion responses to compensate variations in nutrient composition of the rearing substrate. To this purpose, we compared insects grown on a nutritionally balanced diet for dipteran larvae and a nutritionally poor diet that mimics fruit and vegetable waste composition, a substrate produced in large amount worldwide, whose use is allowed in the European Union for the mass rearing of insects that are used for the production of fish feed. Our morphofunctional characterisation of the midgut responses, supported by a transcriptomic analysis, shows a diet-dependent adaptation process of the midgut that allows the larva to fully exploit the unbalanced diet, with minor effects on the growth performance. Besides differences in cell morphology, activity of digestive enzymes, and accumulation of long-term storage molecules, midgut cells of larvae grown on fruit and vegetable waste show differential expression of genes coding for digestive enzymes, transport proteins, and immune factors. Our data demonstrate that the functional plasticity of the midgut has a key role in the ability of BSF larvae to grow and develop on substrates with low nutrient content.