Seasonal variance of HO.RE.CA. leftovers as a feeding substrate for black soldier fly (*Hermetia illucens* L.) larvae

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To cope with the management of bio-urban waste, the SCALIBUR project (Horizon 2020) proposes to explore innovative solutions, including the use of black soldier fly larvae (BSFL), *Hermetia illucens* (Diptera, Stratiomyidae) for the bioconversion of HO.RE.CA. (Hotel-Restaurants-Catering) leftovers. In this framework, the use of BSFL represents a sustainable solution, capable of addressing the solid waste problem and efficiently delivering a large amount of biomass rich in protein, fat, and chitin (Barragan *et al*, 2017; Liu *et al*, 2019; Montevecchi *et al*, 2019).

A highly frequented canteen, or cafeteria, is an abundant source of HO.RE.CA. leftovers to be evaluated in this project. However, the quality of food residues might vary in relation to several factors: availability of fresh products such as fruit and vegetables; different requests for food in cold and hot seasons; expectations of canteen patrons. Moreover, all the aforementioned reasons are reflected in a greater quantity of seasonal food leftovers with a higher water content during the summertime, while a higher quantity of products with low water content and with a higher protein and lipid content is available during wintertime. As a consequence, the variability of canteen leftovers may have a negative influence on BSFL performances when used as a rearing substrate for an all-year production.

This report describes some of the main results of the research, in particular the evaluation of the variability in water and proteins present in the HO.RE.CA. leftovers which were withdrawn from a local canteen over a 12-month period and the relationship with (i) the growth parameters of the larvae, (ii) the reduction of the initial substrate, and (iii) the percentage of the residual substrate (frass) mechanically separated at the end of the rearing process.

Three replicas were performed for each lot of HO.RE.CA. leftovers collected. The trials were conducted in a climatic chamber at 27.0 ± 0.5 °C and 70 ± 10% relative humidity, using a larval density of 5 larvae/cm^2 and approximately 0.70-0.76 g of feeding substrate/larvae, all administered at the beginning of the experiment. When the first pupae were observed, the rearing procedure was concluded and the mature larvae were separated from the frass through a mechanical sieve and subsequently weighed. The percentage of substrate reduction and the mechanically separated frass were assessed based on their wet weights. Samples from the fresh HO.RE.CA. leftovers used as a feeding substrate were oven-dried at 60 °C, ground, homogenized, and subjected to the determination of the crude protein content (Kjeldahl apparatus).

Table 1 shows the results of BSFL performances. Since the number of observations was not suitable for a parametric correlation test, a nonparametric test (the Spearman rank order correlation) was used, thus relaxing the hypothesis of normal distribution of the data. A significant correlation ($r = 0.96$; $p < 0.001$) was found between the HO.RE.CA. substrate's proteins and the mature larvae average weight (Fig. 1). This is the most remarkable data that substantiates how the amount of proteins present in the HO.RE.CA. feeding substrate is the main factor that influences BSFL growth.

The statistical test did not show any significant correlation between the amount of water contained in the initial fresh HO.RE.CA. leftovers and the substrate reduction nor the percentage of separable frass (Fig. 2) at the end of the rearing process. Furthermore, the hypothesized consequences on food residues of higher water quantity in the HO.RE.CA. leftovers in the summer months did not occur. Moreover, the water content seems to be in an optimal range for the BSFL development regardless of the season. Short-term weather conditions and mean seasonal temperatures or relative moisture values are the factors that can considerably affect water evaporation during the rearing process.

Although HO.RE.CA. leftovers are a suitable feeding substrate because the addition of water is not required, it is essential to include specific thermo-hygrometric control systems in the rearing plant to achieve a high level of frass and mature larvae separation.

Table 1. Results of BSFL performances under different HO.RE.CA. leftover compositions.

Month	HORECA leftover dry matter (% FW)	HORECA leftover moisture (% FW)	HORECA leftover protein (% DW)	HORECA leftover protein (% FW)	Larval average weight (g)
Sep 2020	19.20	80.80	17.93	4.26	0.14
Nov 2020	22.00	78.00	19.69	5.55	0.16
Jan 2021	23.20	76.80	9.46	2.86	0.12
Feb 2021	21.60	78.40	14.24	3.92	0.14
May 2021	24.30	75.70	18.39	5.90	0.17
Jun 2021	15.90	84.10	17.47	3.30	0.13
Jul 2021	27.60	72.40	12.32	4.70	0.16

Figure 1. Spearman rank order correlation between HORECA leftovers protein (% FW) and larval average weight (g).

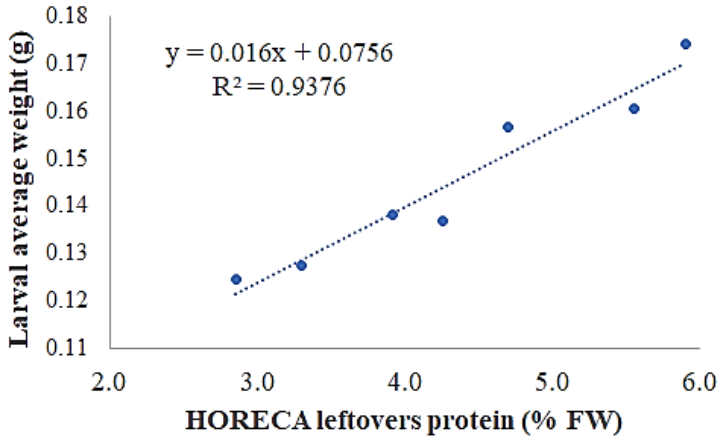
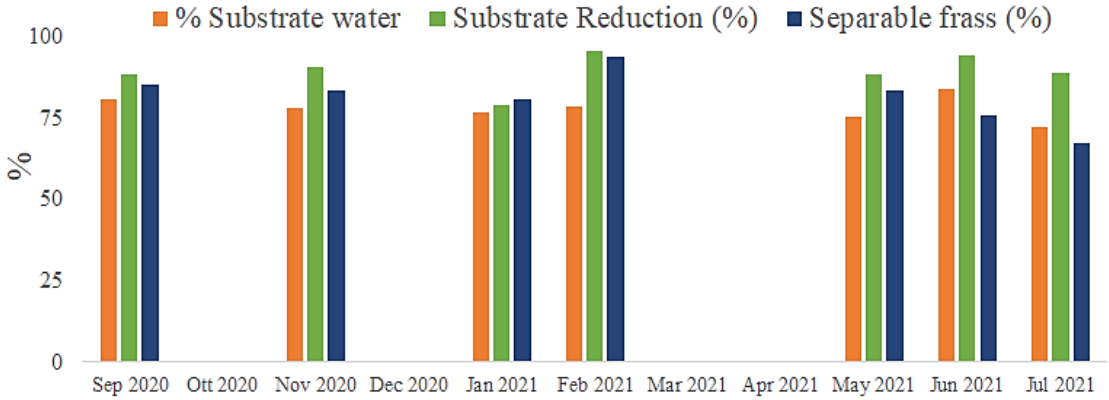


Figure 2. Comparison among water contents of the substates with substrate reduction (% FW) and percentage of separable frass (% FW).



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