Extraction and functional properties of proteins from black soldier fly (*Hermetia illucens*) reared on canteen waste

Lucian Miron[1], Giuseppe Montevecchi[2], Andrea Antonelli[2], Menno Thomas[1]

[1] Zetadec BV, Agro Business Park 44, 6708, PW, Wageningen, The Netherlands
[2] Department of Life Science (Agro-Food Science Area), BIOGEST - SITEIA Interdepartmental Centre, University of Modena and Reggio Emilia, Piazzale Europa 1, 42124 Reggio Emilia, Italy
Keywords: Hermetia illucens, protein extraction, functional properties, alternative proteins
Presenting author email: lucian.miron@zetadec.com

There is an increasing need for sustainable protein sources in the world because of an increasing world population (FAO, 2009). Black soldier fly larvae (BSFL) are emerging as an alternative source for both food and feed, since they contain approximatively 42% crude proteins (Diener *et al*, 2009) which contain all amino acids required for human consumption (Yi, 2015). Before the proteins can be effectively used within the food industry, they need to be separated from lipid and chitin fractions. To increase consumer acceptance, the insect proteins can be incorporated in food products (House, 2016). The protein content is not the only important factor when trying to incorporate a new protein source in food products. The functional properties like solubility, water and oil binding, and emulsification play a significant role in the adoption of a new protein source. To our knowledge, the functional properties of *Hermetia illucens* have been investigated in only one study (Bußler et al., 2016).

The aim of this research was to develop an extraction method in order to obtain a protein fraction with high yield and purity. The functional properties were determined and compared to a reference protein source.

BSFL reared on canteen waste were obtained from University of Modena and Regio-Emilia, Italy. Commercial BSFL were purchased from Top Insect bv. The BSFL were defatted with ethanol and then three extraction parameters: pH, solvent:material ratio and time were optimized using a Box-Behnken design. The protein solubility was measured using a method of Boye *et al* (2010). Water binding capacity was determined according to the AACC method 56-30.01 (AACC, 2000) and the fat binding capacity was measured according to the method of Lin *et al* (1974). Emulsifying capacity was determined similarly to Pearce and Kinsella (1978).

The contours of the Box-Behnken design are plotted in Figure 1. The highest yields are in the upper-right corner of the plot. Thus, increasing each variable tends to increase the protein yield.

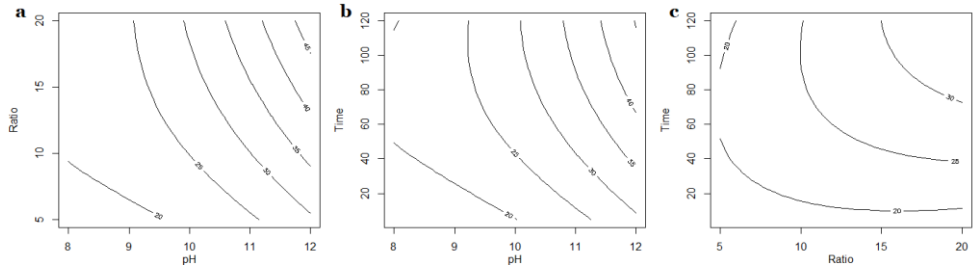

Figure 1. Response surface contours for extraction yield. a) pH vs ratio b) pH vs time c) ratio vs time.

The solubility of the four different protein samples was tested over a pH range of 1-10 (Figure 2).

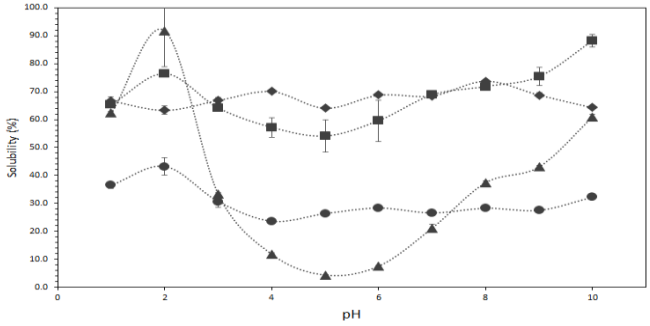

Figure 2. The protein solubility of defatted larvae (DBSF) (●), commercial BSF protein isolate (CBSFI) (■), canteen waste BSF protein isolate (BSFI) (▲) and whey protein isolate (♦).

In general, the solubility of proteins is high excepting at isoelectric point, where the solubility decreases due to the lack of repulsion between proteins. This is also observed in the BSFI and CBSFI at pH 5, where the solubility is lowest. The solubility of WPI is also shown and is the same over the whole pH.

The water absorbing capacity for DBSF, CBSFI and BSFI are approximatively 165, 161, and 303% respectively. The fat absorbing capacity were found to be approximately 112, 302 and 308% respectively (Figure 3).

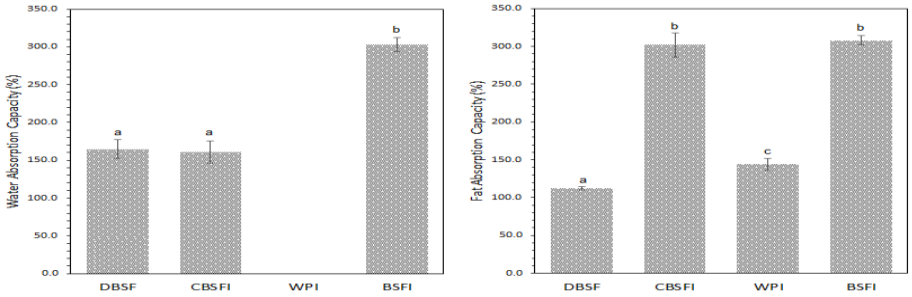

Figure 3. Water absorbing capacity (left) and fat absorbing capacity (right) of the defatted larvae (DBSF), commercial BSF protein isolate (CBSFI), organic waste BSF protein isolate (BSFI) and whey protein isolate (WPI). Different letters represent significant differences ($p \leq 0.05$).

The EAI of the samples range from the lowest of 17 for DBSF to 59 for WPI, with each sample being significantly different ($p \leq 0.05$). This suggests that the whey protein isolate forms better emulsions than all BSF samples.

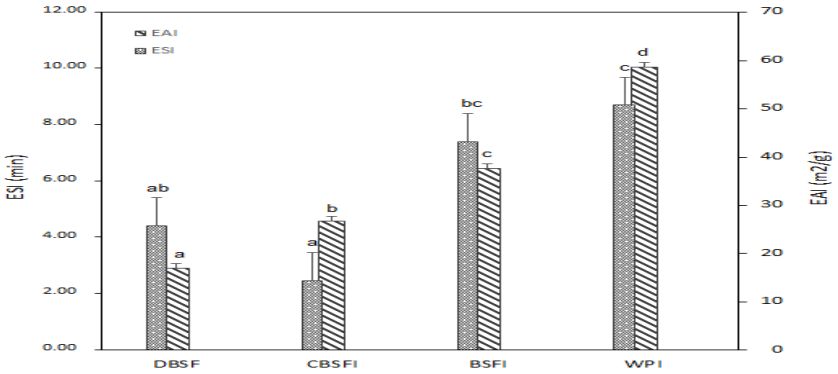

Figure 4. The emulsifying capacity index (EAI) and emulsion stability index (ESI) at pH 7 of the defatted larvae (DBSF), commercial BSF isolate (CBSF), canteen waste BSF protein isolate (BSFI) and whey protein isolate (WPI). Different letters represent significant difference ($p \leq 0.05$).

By decreasing the pH from severe alkaline conditions (0.1M-1M) NaOH as found in literature to a pH of 12 (0.01M NaOH), this extraction method is more suitable to be implemented in industry because results in higher protein quality. In general, the BSF proteins showed good solubility excepting the isoelectric point. The water binding capacity showed values ranging from 161 to 303%, comparable to other insect proteins. The fat binding capacity showed values ranging from 112 to 308%. These values are higher than other protein sources such as lentil protein isolates. The BSF proteins showed good emulsifying properties but lower compared to whey protein isolate.

AACC International (2000). Method 56-30.01 water hydration capacity of protein materials

Boye, J. I., Aksay, S., Roufik, S., Ribéreau, S., Mondor, M., Farnworth, E., & Rajamohamed, S. H. (2010). Comparison of the functional properties of pea, chickpea and lentil protein concentrates processed using ultrafiltration and isoelectric precipitation techniques. Food Research International, 43(2), 537–546.

Bußler, S., Rumpold, B. A., Jander, E., Rawel, H. M., & Schlüter, O. K. (2016). Recovery and techno-functionality of flours and proteins from two edible insect species: Meal worm (Tenebrio molitor) and black soldier fly (Hermetia illucens) larvae. Heliyon, 2(12)

Diener, S., Zurbrügg, C. & Tockner, K. (2009). Conversion of organic material by black soldier fly larvae: Establishing optimal feeding rates. Waste Management and Research, 27, 603–610.

FAO (2009). Global agriculture towards 2050. Rome. High-Level Expert Forum.

House, J. (2016). Consumer acceptance of insect-based foods in the Netherlands: Academic and commercial implications. Appetite, 107, 47–58.

Lin, M. J. Y., Humbert, E. S., & Sosulski, F. W. (1974). Certain functional properties of sunflower meal products. Journal of Food Science, 39(2), 368–370

Pearce, K. N., & Kinsella, J. E. (1978). Emulsifying Properties of Proteins: Evaluation of a Turbidimetric Technique. Journal of Agricultural and Food Chemistry, 26(3), 716–723

Yi, L. (2015). A study on potential of insect protein and lipid as food source. PhD Thesis. Wageningen University.

Results incorporated in this study originate from the SCALIBUR project, which received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817788