SUPPLEMENTARY MATERIALS

The Application of Life Cycle Assessment to Evaluate the Environmental Impacts of Edible Insects as a Protein Source

Giuliana Vinci [1,*], Sabrina Antonia Prencipe [1], Luca Masiello [1] and Mary Giò Zaki [1]

[1] Department of Management, Sapienza, University of Rome, Via del Castro Laurenziano 9, 00161 Rome, Italy; sabrinaantonia.prencipe@uniroma1.it (S.A.P.); luca.masiello@uniroma1.it (L.M.); marygio.zaki@uniroma1.it (M.G.Z.).
* Correspondence: giuliana.vinci@uniroma1.it

S2.1.2. Functional unit (FU)

Mealworm protein was estimated as the amount of nitrogen multiplied by 6.25, a typical conversion factor that is also used for insects [28]. The protein content of mealworms was calculated to be 53.78% based on dry matter (DM). Since nitrogen is not only found in protein but is also bound to the chitin of the mealworm exoskeleton, the determined average nitrogen values were subtracted based on reported chitin-bound nitrogen values of 5-6% [29]. Taking into account the DM content at harvest (27%) and an edible portion of 94.5% (without chitin), 1 kg of mealworm protein requires 7.30 kg of live mealworm mass. Whereas, for pork production, the edible protein fraction was calculated following the proportions found in the study by [30], which initially distinguishes between the edible fraction, i.e. meat plus edible organs and tissues, and the live weight product (LWP), which represents the actual weight of the animal before slaughter. The calculation for pork is carried out as follows:

(1) 1 kg LWP = 0.60 kg edible fraction → 1 kg edible fraction = 1.66 kg LWP

Then the protein content within the edible fraction is calculated, which for pork corresponds to the following ratio:

(2) 1 kg edible fraction = 0.150 kg edible protein → 1 kg edible protein = 6.66 kg edible fraction

Summarizing by relating 1 kg of edible protein to the LWP, we obtain the following formula:

(3) 1 kg edible protein = (1.66 x 6.66)kg LWP → 1 kg edible protein = 11.05 kg LWP

S2.2. Life Cycle Inventory (LCI)

The mealworm system production accounts for the feeding of the parent stocks and the process of rearing, killing, and storing mealworms. Concerning mealworms' feed supply, the quantity in kg of each type of ingredient (i.e., maize, grain, etc.) was calculated on the basis of the total percentage composition of the dry mixture. The feed mixture was composed of wheat bran (70%), maize (12%), brewer's yeast (10%), and lucerne (8%). On-farming electricity consumption for feed, rearing, and storage processes were recorded and elaborated based on data collected from [25]. The average low-voltage electricity mix was used, which ensures that electrical equipment within certain voltage limits (50 and 1000 V for alternating current; 75 and 1500 V for direct current). Diesel consumption for transportation from field to mealworm gate for all feed ingredients was calculated based on fuel consumption data sheet for crop and livestock use, according to Dreyer et al., 2021 [25].

The life cycle inventory of pork production considered feeding, fattening, and slaughtering processes data. Feed supply amounts were calculated based on Reckmann et al., 2013 [27], thus by relating the quantities to the functional unit considered in the study (1 kg of edible protein).

Pork feeding, fattening, and slaughtering electricity consumption for machinery and rearing facilities was calculated considering the low-voltage electricity mix based on Ecoinvent database, thus considering the transmission of 1 kWh electricity at low voltage, which started from fed into the transmission network, and ended with the transport of 1 kWh of low voltage electricity in the transmission network over aerial lines and cables. For field operations, the average hourly fuel consumption was taken into account, corresponding to about 42 l/h and relating it to the distance, about 10 km. While, for the transport of animals to the slaughterhouse, a distance of 40 km was considered [27]. All data have been related to the FU considered in the study.

References

25. Dreyer, M., Hörtenhuber, S., Zollitsch, W., Jäger, H., Schaden, L. M., Gronauer, A., & Kral, I. Environmental life cycle assessment of yellow mealworm (Tenebrio molitor) production for human consumption in Austria – a comparison of mealworm and broiler as protein source. International Journal of Life Cycle Assessment, 2021, 26(11). https://doi.org/10.1007/s11367-021-01980-4

27. Reckmann, K., Traulsen, I., & Krieter, J. Life Cycle Assessment of pork production: A data inventory for the case of Germany. Livestock Science, 2013, 157(2–3). https://doi.org/10.1016/j.livsci.2013.09.001

28. Miglietta, P. P., de Leo, F., Ruberti, M., & Massari, S. Mealworms for food: A water footprint perspective. Water (Switzerland), 2015, 7(11). https://doi.org/10.3390/w7116190

29. Barker, D., Fitzpatrick, M.P. and Dierenfeld, E.S. Nutrient composition of selected whole invertebrates. Zoo Biol., 1998 17: 123-134. https://doi.org/10.1002/(SICI)1098-2361

30. Flachowsky, G., Meyer, U., & Südekum, K. H. Land use for edible protein of animal origin—A review. In Animals 2017, 7(3). https://doi.org/10.3390/ani7030025