Sustainability & Circular Economy

Towards more sustainable and circular food production systems: Life cycle assessment of pumpkin pulp production using conventional and alternative preservatives

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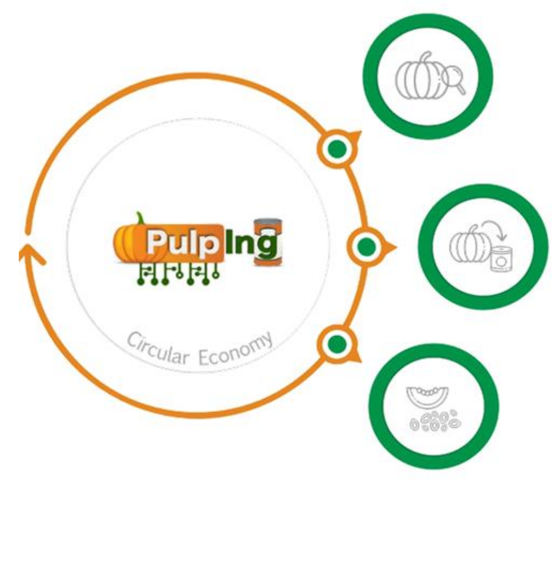
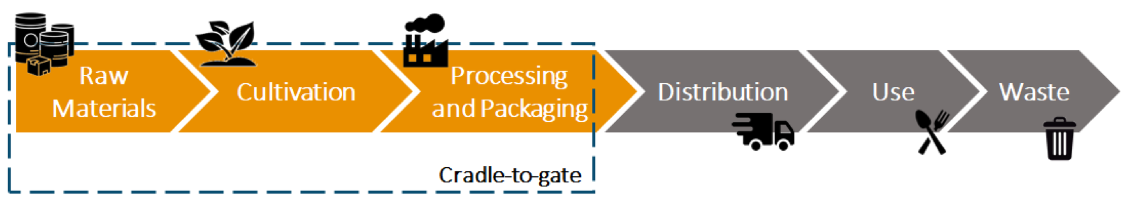
Overview

The agri-food chain is one of the sectors with the greatest environmental impacts and is identified as an area of major sustainability concern due to its contributions to climate change, land use, depletion of freshwater resources, air emissions, and waste generation [1]. Therefore, the complete life cycle of crops must be considered, and life cycle assessment is a proper tool for this purpose [2].

The **Project *PulpIng*** ***"Development of pumpkin pulp formulation using a sustainable integrated strategy"*** aims to stimulate a value chain with novel processes that go throughout all developing stages of **pumpkin fruit pulp formulation** functionalized with a **natural-based preservative** extracted from **pumpkin by-products**, replacing conventional preservatives, which usually come from non-renewable resources. Therefore, in the present study, the **Life Cycle Assessment** (LCA) methodology was applied to evaluate the **potential environmental impacts** resulting from the production of pumpkin pulp. In the first stages of the work, different scenarios of pumpkin by-product disposal during the agriculture phase were evaluated and studied. This evaluation is important since the inadequate treatment of these can result in additional environmental impacts, considering their fundamental valorization [3].

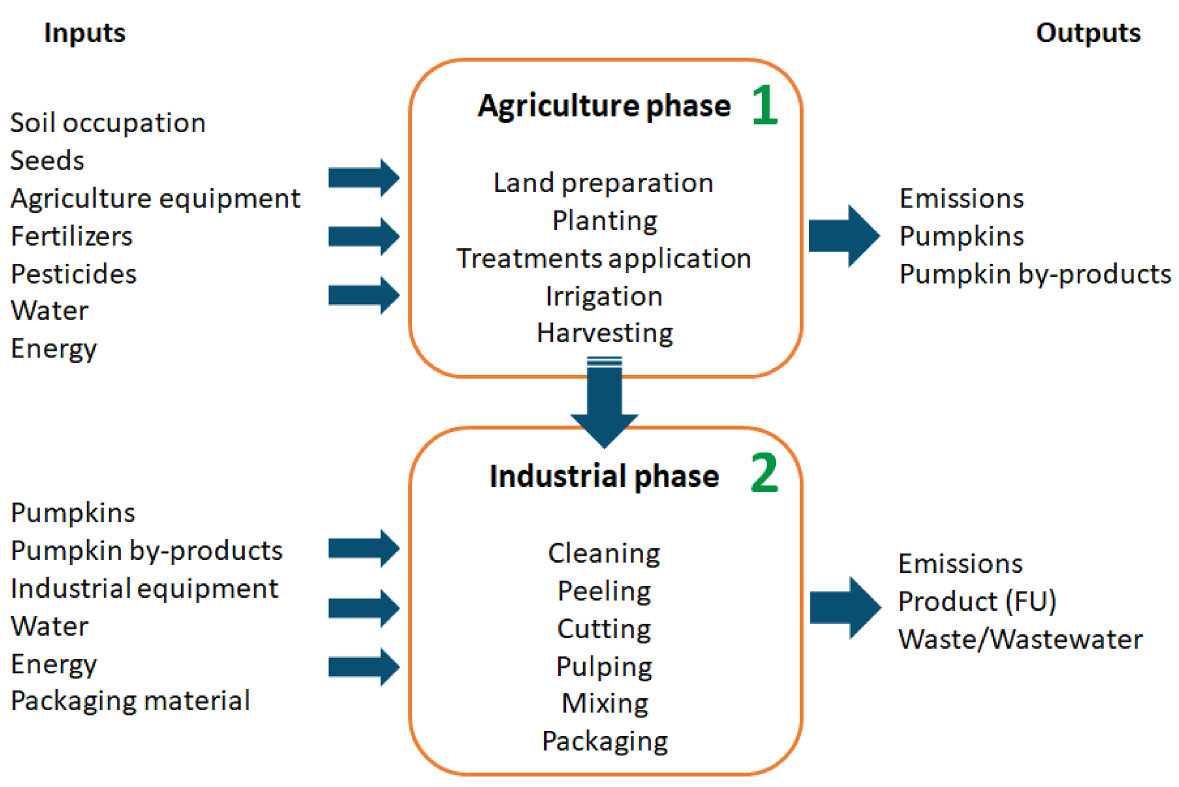


Life cycle assessment



All life cycle stages of pumpkin pulp production, up until the product is ready for distribution, will be accounted for. **Distribution and consequent stages are not considered as no changes are expected**, despite the alterations in pumpkin pulp formulation.

Hence, two main steps will be assessed: the **agricultural phase**, up until the pumpkin flesh is obtained; and the **industrial phase**, up until the final pumpkin pulp is produced.

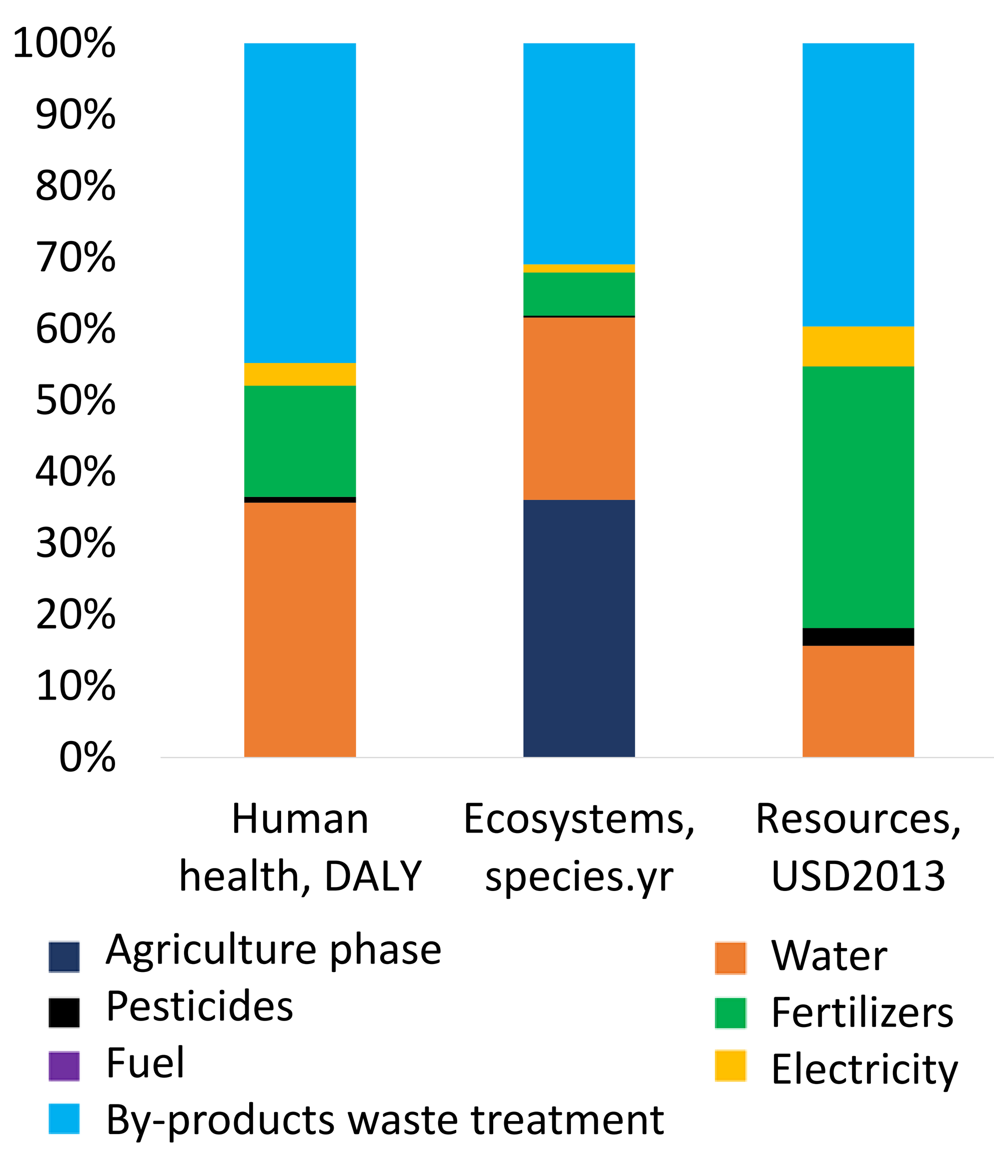


Preliminary results are available for the agriculture phase. Data for the agriculture phase was obtained from experiments performed at pilot-scale in Greece:

- **Open-field cultivation (1280 m^2)**
- **6 months**
- **320 pumpkins**
  5.8 kg of pumpkin flesh/pumpkin
- **1.79 kg of by-products (*e.g.* stems, leaves, rinds) per kg of pumpkin flesh**

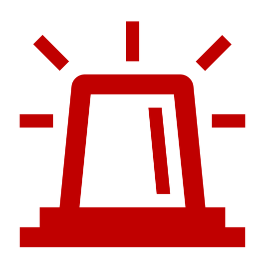
Results

Preliminary results for the production of **1 kg of pumpkin flesh**, using the **ReCiPe** methodology and data from the **Ecoinvent v3** database.



- Under the studied conditions, it is estimated that **the treatment of the by-products of pumpkin flesh production (considering an average treatment around the World for the biowaste)**, is a **significant contributor to most potential environmental impacts** generated by the agriculture phase.
- In fact, this **biowaste treatment** is the **main contributor to 10 out of 18 evaluated midpoint categories**, and the 2nd main cause for 4 other impact categories.
- On average, **the biowaste treatment step contributes to 42 % of the total potential midpoint impacts of the agriculture step**, varying between 0.2 % to water consumption to 98 % of marine eutrophication.
- These results are reflected at endpoint (damage) level: the biowaste treatment contributes to **45 % of the potential impacts on Human Health, 31 % to Ecosystems, and 40 % to Resources**.

Given that biowaste treatment practices may vary around the World, several scenarios were tested.



- **Treatment by deposition in open dumps results in the highest potential impacts of the agriculture phase on Human Health and Ecosystems** (50 % or higher impacts than if the by-products are treated by anaerobic digestion, industrial composting or incineration). Industrial composting has the highest impact on Resources.

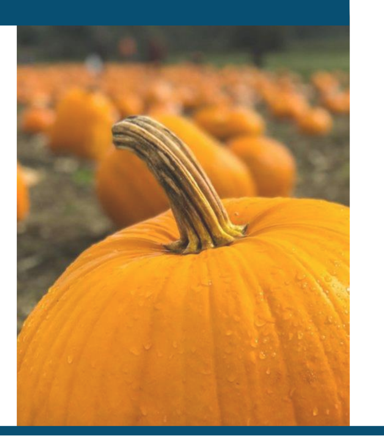
- **Anaerobic digestion or incineration of the by-products could potentially reduce the impacts** of the agriculture phase, relatively to industrial composting or open dump deposition, depending on the impact category. Nonetheless, the contribution of biowaste treatment to the damage resulting from the agriculture phase is still of 20 % on average.

Infrastructure and machinery production, seeds, and CO_2 adsorption during plant growth were excluded as per the literature. Modelling of the distribution of fertilizers and pesticides over the environmental compartments is not yet included.

Conclusions and Future Perspectives

These preliminary results show that the by-products of pumpkin, which are a biowaste for the pumpkin pulp production chain, may indeed have a meaningful contribution to the **potential environmental impacts for the agriculture phase** and thus, possibly to the whole life cycle of pumpkin pulp. Hence, it is fundamental to **develop alternatives to the current biowaste treatment practices** and, if possible, give proper use to these by-products.

This work is thus of great interest and will continue to be developed. The inventory data for the agriculture phase will be refined, and the potential impacts for the industrial phase will be estimated, using data from a real producer. The life cycle assessment will then be performed incorporating the reclamation of the pumpkin by-products for the production of an alternative preservative for pumpkin pulp and the potential avoided impacts will be estimated.



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