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Environmental Performance of an Innovative Food Processing Technology for the Preservation of Spinach

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An innovative freezing method for the preservation of spinach has been developed and patented at Lund University in Sweden. This method makes fresh, locally grown spinach available all year long. The technique is based on the use of trehalose, a natural sugar (devoid of sweet taste) found in yeast and certain insects, fungi and types of grass that all survive cold temperatures better than other plants and vegetables. Trehalose prevents cells from bursting due to ice crystals forming.
The vegetables are first put in a vacuum machine, and the air is extracted. Water containing the trehalose is then injected and replaces the air in the tissue. To make sure the substance is both inside and outside the cells, a small electrical pulse is applied in order to penetrate the outer cell membrane. The vegetables are then frozen after a few hours.

Whereas the practical interest of the preservation technique seems obvious, the environmental impacts associated to such a process have to be questioned. Hence, the first aim of this study was to estimate the environmental impact of the freeze protection of spinach and subsequent changes in the supply chain. The scope of the study was "cradle to retail" following the ISO 14044 methodology. Two systems were thus studied and compared: fresh spinach produced, packed and transported within Sweden for selling and the new system where spinach is produced, freeze protected and transported within Sweden for selling. For both fresh and frozen spinach, two scenarios were considered: local *vs* far-distance between cultivation, processing and distribution.
The second aim was to quantify uncertainties of results to increase understanding of the critical points in the supply chain and to support informed decision making.

Data and their uncertainties were obtained all along the supply chain, *i.e.*, for cultivation, processing, packaging, storage and transports stages through the results of the European PRESERF project (Processing Raw Materials into Excellent and Sustainable End products while Remaining Fresh, FP7). Uncertainties outlined the precision that could realistically be assumed when collecting the data, and they were determined from experimental measurements and knowledge of experts but also databases and literature data. Furthermore, by using Monte Carlo simulations, the probability of the environmental impacts of frozen spinach being lower than the impacts of fresh spinach as a function of the distribution distance could be estimated.

The LCA results provided a detailed understanding of the environmental hotspots for both fresh and frozen spinach. The comparison between fresh spinach distributed far away and frozen spinach locally distributed could be discussed. In addition, this study highlighted the interest of uncertainty analysis as a valuable tool in the evaluation of novel food processing technologies.

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