Comparative Life Cycle Assessment of Fresh and Processed Spinach

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Introduction

- Spinach is an excellent source of vitamin A, vitamin C, vitamin K, as well as iron, calcium, and magnesium.
- Fresh spinach is preferred by consumers, but it has a lower shelf life than frozen and canned spinach.
- Handling and processing can affect Food Loss and Waste (FLW), as well as the nutritional composition.
- Processing of spinach increases the overall shelf life of the final product which could help reduce food wastage.
- Food production contributes to 35% of overall greenhouse gas emissions.
- Waste generation by food is about 59.7% as per the WARM Version 15, November 2020 model.
- It is important to consider cumulative food losses caused by varying shelf life and supply chain requirements that can lead to varying environmental impacts.
- The study is expected to guide decision making by consumers and policymakers to balance nutritional and sustainability elements of the spinach supply chains.

Goal and objective

- To determine and compare the food loss, wastage, and resource use metrics of frozen, fresh, and canned spinach.
- To compare the nutritional content of fresh and processed spinach.
- To assess the environmental impacts in a Life cycle Assessment (LCA) study by analyzing the supply chain from farm gate-to-table.
- To suggest improvement actions to be applied to reduce food loss and wastage.

Functional Unit

The functional unit considered in this study is 1 kg of fresh spinach.

System boundary

- The product chain stages included are processing, transportation, storage, retail, consumption and waste management of frozen, fresh, and canned spinach as shown in Figure 1, Figure 2, Figure 3.
- Production phase of spinach is common for fresh, frozen and canned spinach.
- Distribution of spinach includes transportation from food processing unit to retail stores and from retail stores to consumers.

Materials and methods

- LCA tool is used to analyze and compare the impact of processed spinach with respect to greenhouse gas emissions.
- Food loss and wastage is evaluated from U.S. Environmental Protection Agency's Waste Reduction Model, WARM Version 15, November 2020.
- U.S. Department of Agriculture food database April 2019 is used for creating nutritional chart of fresh and processed spinach

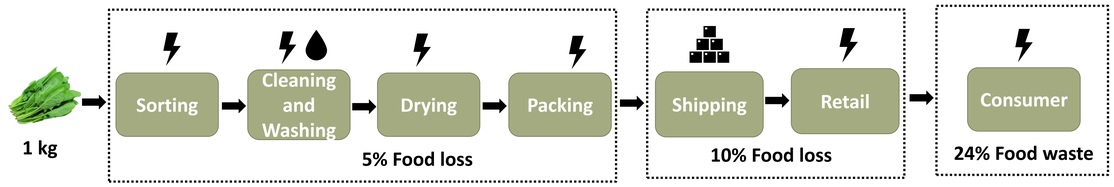


Figure 1: Unit operations in fresh spinach

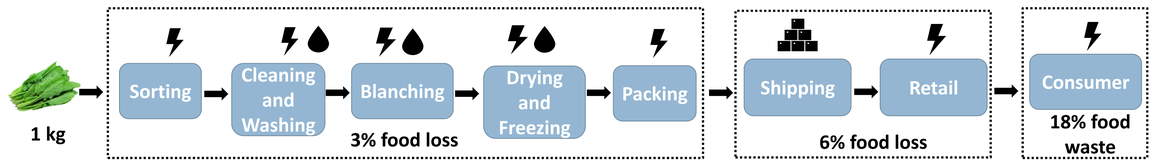


Figure 2: Unit operations in frozen spinach

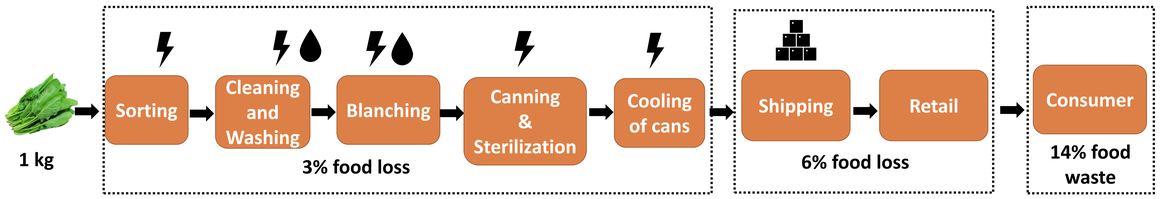


Figure 3: Unit operations in canned spinach

Discussion

- Shelf life of fresh spinach is 5-7 days, frozen spinach is 12 months and canned spinach 2-3 years, and hence maximum food wastage is from fresh spinach.
- Fresh spinach price is low hence consumers purchase it even if not required and are not affected if the spinach is spoilt.
- The total food loss and waste of spinach from processing to consumer phases is represented in figure 4.

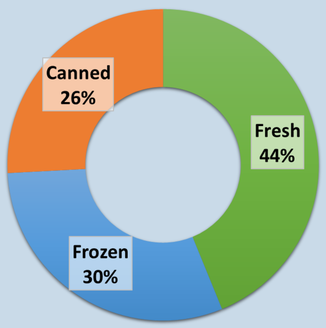
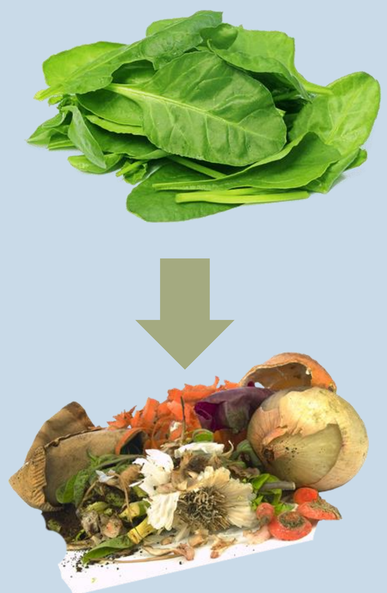


Figure 4: Total Food Loss and Waste for Spinach



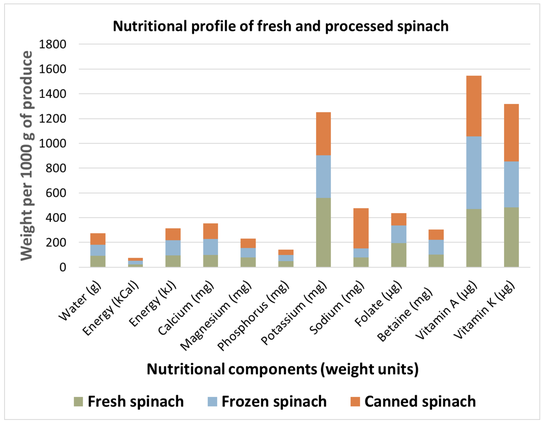


Figure 5: Nutritional profile of fresh and processed spinach

- Figure 5 highlights that nutrient content of processed food is similar and, in some cases, higher than fresh food.
- GHG emissions are maximum for processing of canned spinach post which the emission is comparatively less.
- For fresh and frozen spinach, the maximum emission is during retail and consumer stage due to its storage condition.

Conclusion

- Food loss during transportation and processing is unavoidable loss and food wastage is when food is not edible for human consumption which is avoidable.
- Procedures can be established for food wastage by following the WARM Version 15 cycle of recycling, landfilling, composting, collection and transport to anaerobic digestors.
- It is important to analyze the food loss at each processing stage and evaluate the GHG emission since canned food might consume more energy initially, but it results in less energy consumption at consumer level and less food wastage making it accessible for countries with food deficiency.
- LCA can be applied to make an overall product cycle analysis and be used in spreading awareness and stimulating dietary changes leading to reduction of GHG emissions.

Future Work

- Using SimaPro version 9.3 to quantify environmental impacts such as global warming, acidification, eutrophication, ecotoxicity, fossil fuel depletion from the production stage to processing stage.
- To study the impact of spinach production, packaging and transportation contributing to food loss.

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