An assessment of environmental impacts of cassava starch extraction technologies

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Introduction

The environmental impacts of the transformation of cassava roots into starch were assessed for three contrasting technologies at small (ST1, ST2) and very large scale (VLT), meaning 1-2 and 100-200t starch per day, respectively. The goal of the study was to assess energy and water use for each unit operation, so as to identify high usage hotspots. The Life Cycle Assessment (LCA) framework was applied in order to test its relevance as a tool to analyze unit operations' environmental performance, for process eco-engineering purposes.

Results

Energy and water consumption varied widely between technologies (figures 2 & 3). The large scale technology required 702kWh/t starch, mainly (75%) from fuel oil used for the drying operation, but was the most efficient in terms of water use (10m^3/t starch) due to the practice of water recycling between unit operations. The two small scale technologies were similar in terms of electricity use (59kWh/t starch), and were able to rely on solar energy for drying, due to the small volumes of production. In contrast, water consumption varied from 20 to 60m^3/t starch between the two small scale technologies due to differences in the design of the rasping and starch recovery (extraction) operations.

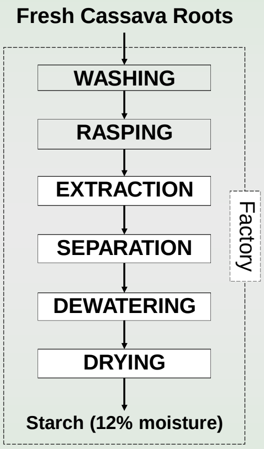

Figure 1: Unit operations of the cassava starch extraction process. The dotted line represents the selected system boundaries.

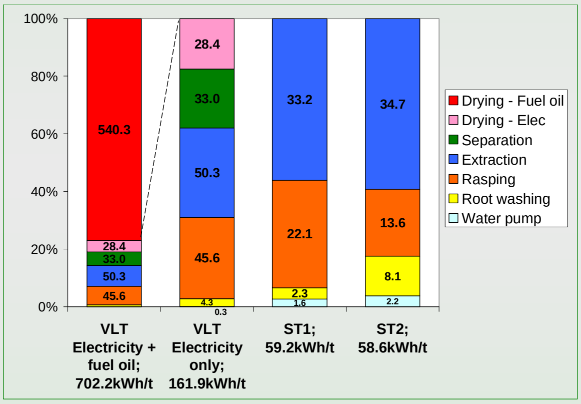

Figure 2: Energy consumption by unit operations of VLT, ST1 and ST2 technologies (large, small 1 and small 2 respectively). The figures within the bars and on the horizontal axis indicate actual energy use per operation and total energy use respectively, in kWh/t starch.

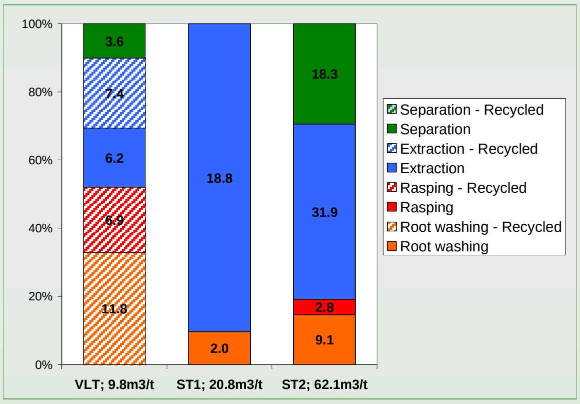

Figure 3: Freshwater consumption by unit operations of VLT, ST1 and ST2 technologies. The figures within the bars and on the horizontal axis indicate actual water use per operation and total water use respectively, in m^3/t starch.

Methods

The system boundaries were defined as the unit operations used to transform fresh cassava roots delivered at factory gate into loose, dry cassava starch (figure 1). The functional unit (FU) was defined as one ton of loose, dried cassava starch (i.e. starch at 12% moisture content on a wet weight basis, wwb), obtained at the end of the manufacturing process.

Primary data for ST1 and ST2 factories were obtained from the authors' own measurements in collaboration with one cassava starch factory based in Vietnam (suburban Hanoi region) and one based in Colombia (Cauca department). Data for the VLT factory and data related to water and chemicals consumption (e.g. alum, SO_2) were based on measurements published by Piyachomkwan et al. (2005), Sriroth (1996) and Sriroth et al. (2000) in Thailand. The factories surveyed were representative of the standard technology used in the three regions of the study.

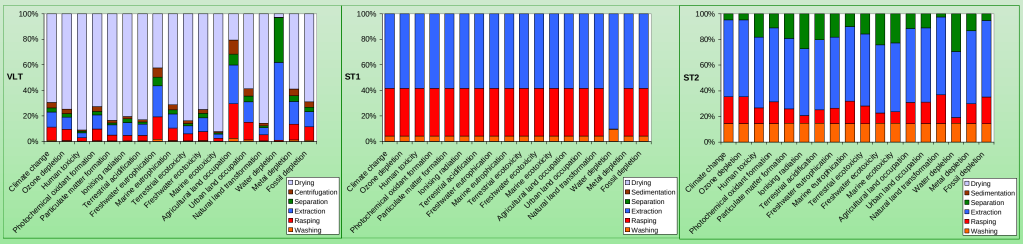

Figure 4: Environmental impacts characterization of the transformation of cassava roots into starch for the very large scale (VLT) and two small scale (ST1, ST2) technologies.

Results (continued)

The LCA characterizations (figure 4), using the ReCiPe method, indicated that the main impact contributions were at the drying operation for the large scale technology, and at the extraction operation for the small scale technologies, mainly because of energy use, as well as water use in the case of the most water-intensive technology.

Conclusions

Among the three technologies assessed, markedly different levels of energy and water consumption were identified for some unit operations, such as extraction or root washing, which indicates the potential for technology transfers and improvements of the overall environmental performance of the cassava starch industry.

This work demonstrates the feasibility and usefulness of applying LCA concepts for integrating environmental performance indicators in the design and evaluation of transformation processes for agro-industrial products. The environmental dimension should come in addition to other aspects including process yields, microbial safety and product quality.

Acknowledgments

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