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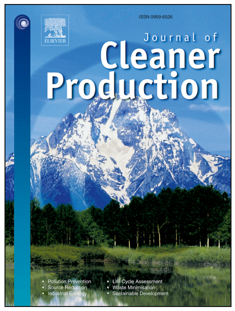

Water and carbon footprint improvement for dried tomato value chain

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Abstract

The water and carbon footprint of the presented dried tomato value chain is compared to the conventional process. The coupling of pre- and post-harvest processes, namely growing and drying respectively, is analyzed for resource consumption optimization. The growing system of tomatoes (*Solanum lycopersicon* L. cv, Pannovy) in an energy efficient greenhouse (operating as a solar thermal collector) is databased; while the post-harvest process consists of a model-based solar drying system. The thermodynamic operation zones (temperature, humidity and enthalpy) are detailed to apply energy interaction between both processes. The results of the monthly record of a season show that the water footprint was reduced from 91 to 51.1 L kg^{-1} with a standard deviation from 53.2 to 12.4 L kg^{-1}. The carbon footprint was reduced from 40.2 to 11 kg kg^{-1} with a standard deviation from 23.9 to 11.4 kg carbon dioxide kg^{-1}. From the observed variation from monthly values, the relevance of the seasonal effect on resources needed for implementing process improvements is highlighted. The use of renewable energy and energy efficiency concepts is shown to have a positive impact when applied at industrial level in 'compound industries' that share sub-processes in the value chains.

Keywords: value chain; process optimization; seasonal analysis; solar drying; greenhouse; water footprint; carbon footprint

1. Introduction

The close relationship between water and energy consumption in the agribusiness sector (Bazilian, et al., 2011) has an impact not only on the final product price but also on resource management. Therefore, the reduction of one or both of these, as well as the reduction of or re-utilization of residues, is of positive economic and environmental relevance. The fact that agriculture has a strong correlation with seasonal factors implies that any process evaluation or improvement should include time factors for planning and logistics. In addition, the current use of the virtual water concept (Allan, 1996) and the greenhouse gas (GHG) effect highlight the importance of assessing in a more precise way the resources embedded in traded agricultural goods.

In the case of value chains, the view that it is worth tackling problems such as process integration or energy interaction (Mateos-Espejel et al., 2011) is increasing. Fig. 1 depicts the analyzed tomato drying value chain, which is made up of seven main sub-processes. This work specifically focuses on growing in greenhouses and the drying sub-processes, based on the fact that both display similar characteristics to be improved: i) high thermal energy requirement to fulfill the operation conditions and to obtain best product quality; ii) different seasonal/time trends for energy and water use; and iii) the need to reduce transportation energy.

In the tomato production phase two priority hotspots for the reduction of GHG emissions are transportation in field production and artificial heating in modern greenhouses (Page, Ridoutt, & Bellotti, 2012). Additionally, different studies imply the high importance of temporal and geographical factors (Poritosh et al., 2008; Karakaya & Özilgen, 2011; Riggi & Avola, 2010; Toor et al., 2006), where the carbon dioxide (CO_2) and water impact varies depending on whether consumption is in- or off-season.