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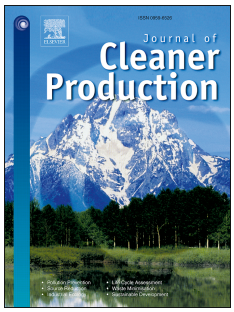

A climate driven decision-support model for the distribution of perishable products

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Abstract

The cold chains prevent perishable products from decay, but are highly energy-intensive. As much as 15% of total worldwide energy already fuels cold chains infrastructures and since 40% of food deliveries would need refrigeration, the growth of global food demand and of the widening of the global supply chains will enormously increase the energy request and the associated carbon emissions. The environmental temperature has indeed a clear effect on the performance of the cold chain, and the interaction between climate and the distribution of perishable products cannot be ignored. In this paper a mixed-integer linear programming model for the planning of the production, storage and distribution operations of perishable products which incorporates the interactions with the weather conditions is formulated. This addresses an open field of research, which is still uncovered. The proposed model has been applied to an illustrative case study of a cold chain for cherries, that demonstrates the influence of the weather conditions on the energy costs for the products refrigeration on vehicles during transportation and at the warehouse during storage. Successful control of the distribution operations according to the weather conditions can result in significant reduction of energy consumption and costs, which increase indeed with the raise of environmental temperatures and stresses. Based on the results obtained in this study, these costs are not handled by the extant operations planning models, and their minimization can lead to significant economic and environmental savings for the cold chain.

Keywords *Cold chain, Perishable, Transport, Optimization, Climate, Energy*

1. Introduction

The management of the distribution of perishable products, like food, needs the perpetual control of the environmental conditions of storage and transport facilities in order to avoid those stresses that may affect their shelf life and quality (Smith and Sparks, 2004). Cold chains, which keep product at low temperatures, are thus used to preserve the products' quality. The cold chains prevent perishable products from decay, but are highly energy-intensive and both their costs and performances are influenced by the climate. The perishability of products and the uncertainty on the environmental conditions experienced throughout the supply chain characterize this challenging environment and make the underlying supply chain more complex and harder to manage than the others (Soto-Silva et al., 2016).

Although cold chains prevent from product' spoilage by reducing growth of microorganisms and slowing physical, biochemical and physiological reactions, different products require different conditions and will be differently managed in the supply chain operations. This awareness is increasingly spreading both in the fields of food science (Vaclavik and Christian, 2014) and operations management (Akkerman and van Donk, 2009). As example, highly perishable products, as fruit and vegetables, can be stored between 4–8°C to avoid alterations in colors and flavors as well as safety threats for the consumers. Notwithstanding we acknowledge the optimal temperatures for the conservation of each product, just 10% of perishable foods are refrigerated and currently

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