

Design of a Sustainable Supply Chain for Fruit Puree Production through Organic Waste Valorization.

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Abstract

In recent years, climate change and its effects have gained significant global attention due to the implications for the environment and people. Presently, its consequences, such as water scarcity, glacier melting, and biodiversity loss, among others, have become global concerns. Drought directly impacts food production by decreasing soil productivity, while the global population continues to increase, implying a higher demand for food. According to the Food and Agriculture Organization of the United Nations (FAO), around one-third of all food produced annually is wasted. Consequently, reducing food waste and reusing food has been set as a significant objective to decrease its carbon footprint.

In Chile, there are various businesses dedicated to marketing fruits and vegetables, such as street markets, the Central Vega, and Lo Valledor. At the end of each sales day, organic waste is generated, collected by the municipal service, and eventually taken to a landfill. Various authors propose reusing this waste in several ways, such as generating biofuels or compost, among others. However, the use of this food for social purposes is not mentioned in the literature.

Given this scenario, the purpose of this project is to support the valorization and management of the food organic waste generated in various city markets. For this, a sustainable supply chain for fruit puree production is developed, implementing a multi-objective optimization model considering different sustainability criteria. We present the production of fruit puree and its subsequent distribution in municipal educational centers of the Metropolitan Region of Chile as a case study, aiming to demonstrate the utility of this research. At first, when implementing the functions in a single-objective manner, favorable results are obtained, always considering the satisfaction of demand, capacity constraints, material balances, among others. For the economic model, benefits are maximized, achieving a net annual profit of \$1,899,334,067.09. Regarding the environmental model, CO₂ emissions during the production process are minimized, obtaining 439675.2 kg of CO₂ eq generated taking into account the fabrication and transport of the product. Finally, from a social standpoint, the final product is distributed, prioritizing the educational establishments from communes with a higher percentage of people in poverty risk, and the demand of all the schools is met. Subsequently, when

implementing the weighted sum for multi-objective optimization, with equal weights for each objective function, the following results are obtained: the benefits decreased to 47.48%, the CO₂ emissions increased by 0.822% and the social function decreased to 59.17%.

In conclusion, the study showcases how a multi-objective approach can address food waste management, climate change, and social equity simultaneously. Despite trade-offs, the sustainable supply chain model for fruit puree production and distribution in Chile proves that it is possible to balance economic, environmental, and social sustainability. It underlines the importance of an integrated approach, serving as a valuable example for future sustainability efforts.

Keywords: Food Waste Management, Supply Chain Design, Sustainability, Multi-Objective Optimization, Organic Waste Valorization.

Acknowledgments: The authors gratefully acknowledge the support and constructive suggestions made for this paper by members of the Program for the Development of Sustainable Production Systems (PDSPS).

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