Environmental Life Cycle Analysis of acai powders obtained by Vacuum Drying

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Colombia is the main exporter of exotic fruits in South America, which in turn has a 15 percent share of the volume of world exports of exotic fruits (Mass Colombia, 2021). As in other Andean countries, fruit growing in Colombia is held mainly by family farmers. Of the more than 400 types of fruit found in the country, there are some whose cultivation and transformation have great potential to promote economic development in areas that were affected by the armed conflict. Its promotion is part of the government plans to accelerate local development in these rural areas and communities.

The açaí (Euterpe oleracea) is a fruit native to Brazil. It grows swamps and floodplains. The pulp has an important nutrients content (such as proteins, lipids and fibers) and is highly energetic (Tonon et al., 2008). In addition, it has bio-compounds such as anthocyanin and carotenoids that have showed therapeutic, anti-inflammatory and anticancer properties (Romualdo et al., 2015).

Thirty percent of fruits and vegetables grown in the world are sold as processed products. Between 2015 and 2019, these products showed growing dynamics of 8% per year with an estimated market value of 63,667 million dollars in 2019. One of the most used techniques for extending fruit shelf life is drying, which reduce its microbial deterioration and may preserve many of nutritional and sensory properties, compared to those of fresh fruit (De Marco et al., 2015). Among drying techniques, vacuum drying has some distinctive features, low drying temperature, and oxygen-deficient processing environment. During this kind of process, the dried product is put to low pressure favoring the preservation of fruit nutrients and bioactives (Jiang et al., 2013).

The LCA in this paper is of an explorative character since large commercial, acai farms are not yet established in Colombia. However, some small-scale pilots have been created in some areas formerly affected by the armed conflict. These pilots provide insight in acai cultivation for fresh fruit production and its transformation to dried pulp or fruit powders. That is why understandings also needed on how to minimize the environmental impacts of the added-value products like the dried acai powders. The aim of the LCA in this work was to explore the future dried acai production systems in order to identify directions for its optimization from an environmental point of view.

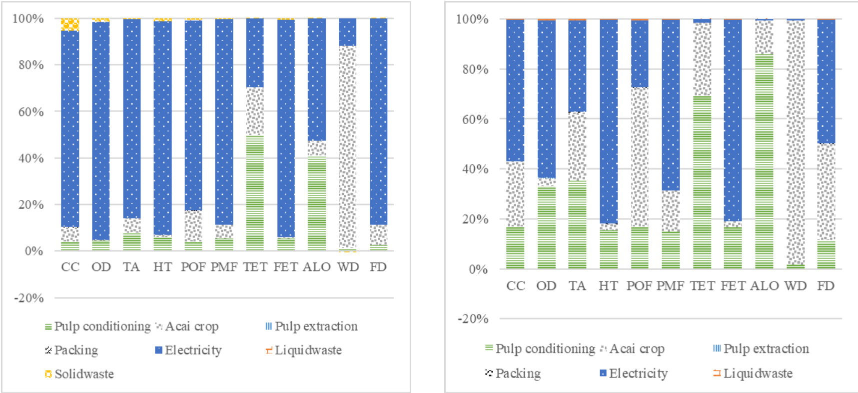
In this work, a gate-to-gate Environmental Life Cycle Assessment (LCA) analysis was performed to compare two processes 1) açaí powder production by vacuum drying, 2) açaí powder production by vacuum drying including solid waste explotation as a new value-added product (organic fertilizer). Both processes were divided into two systems, the system 1 representing the method for obtaining of the açaí pulp and system 2 for the drying of MD-acai pulp.

The açaí fruit was obtained from local growers in Quibdó-Choco, Colombia. The fruit was washed, sanitized and blanched before pulping. The average moisture and Brix degrees of the pulp were 89.59% wt and 10 °Brix, respectively. Maltodextrin (MD) was added as a drying aid until the MD-pulp mix reached 30°Brix. Vacuum drying was carried out in an equipment built under own design during 6 hours at 55°C and 17 mbar. The drying tests were done in triplicate and from their results the material and energy balances of the operation were elaborated. The environmental assessment was carried out in accordance with the methodology proposed by ISO 14040. Impacts were calculated in SimaPro v9.1 software (PRé Sustainability, Netherlands) using Ecoinvent database version XXDX The ReCiPe Midpoint characterization method (hierarchical version H) were used.

Figure 1 shows the impact categories evaluated for the two scenarios.

The categories that presented the greatest impact in the scenarios were climate change (CC), depletion of the ozone layer (OD), terrestrial acidification (TA), human toxicity (HT), formation of photochemical oxidants (POF), formation of particles (PMF), Terrestrial Ecotoxicity (TET), Freshwater Ecotoxicity (FET), Agricultural Land Cover (ALO), Water Depletion (WD), and Fossil Depletion (FD). The impacts of pulp extraction, pulp conditioning, electricity consumed for drying and packaging processes, packaging, liquid and solid waste (a,b) were grouped together.

For the drying and packaging processes, the energy used was electrical energy from hydroelectric plants. This energy has a substantially low environmental impact (3.92 kg CO2 eq kWh1) compared to other energy sources (wind and nuclear power have a global warming potential of 30.6 kg CO2 eq kWh-1 and 11.8 g CO2 eq kWh-1 respectively) (Wang et al., 2018).



(a) (b)

Figure 1. Contribution of the main systems to the total environmental impact of açaí powder production under the proposed scenarios (a) scenario 1, (b) scenario 2. Charts have the same color and layout for each contributing element

In both scenarios, electricity consumption is the one that provides the greatest percentage contribution to almost all the categories analyzed. Focusing on climate change, in scenario 1 the production of 1 kg of açaí powder generated 15.6 CO2 eq., while in scenario 2 5.8 CO2 eq., per Kg of powder. Despite this important reduction, due to the use of waste as fertilizer, in such a scenario electricity contributes 5% more (in relative terms, due to the energy consumption of the additional operations required to produce the fertilizer) in the CC category.
To the authors knowledge, this is the first study of the carbon footprint of açaí powder production under any drying method including or not the use of its processing wastes. Other studies have showed that the environmental impacts for food transformation can be reduced with the processing of its residues as cassava starch production with anaerobic digestion its residues reduces in 28% the Co2 eq generation (Lansche, et al., 2020), in citruss processing reduce the CO2 generation include pectin extraction (Satari & Karimi, 2018) . This work allows us to validate that adding value to products, their waste can make a production process more sustainable, and it can applied to environmentally friendly production projects.

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