Economic feasibility of supercritical fluid extraction of antioxidants from fruit residues.

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Extended Abstract.

During the process of extracting juices or pulp from fruit, large amounts of waste are generated during the different stages of the supply chain, from farm to fork (Panda et al., 2016). Many of these residues are rich in valuable compounds such as antioxidants, oils, fibers, fatty acids, isoprenoids, lipids, proteins, saponins and phytoestrogens (Jiménez-Moreno et al., 2019; Plazzotta et al., 2017). These bioactive compounds have a high potential to be used in different industries, such as the pharmaceutical and food industries (Aizpurua-Olaizola et al., 2015). Among the bioactive compounds that have been obtained from fruit residues can be mentioned: limonene in the orange peel (Espinosa et al., 2005), oleic acid, γ-tocopherol and γ-tocotrienol from the peach seed (Espinosa-Pardo et al., 2014; Sánchez-Vicente et al., 2009), lycopene from red-ripe tomato (Bruno et al., 2018), ascorbic acid in mandarin peel as raw material (Al-Juhaimi, 2014). Technologies for the extraction of bioactive compounds can be classified as conventional and non-conventional technologies (Ameer et al., 2017). These last technologies, allows the solution of different problems of the conventional technologies, such as the high amount of solvent, the low selectivity, long extraction times, among other factors that made the conventional technologies not completely viable (Azmir et al., 2013). Among the non-conventional technologies, it is possible to find with Supercritical Fluids Extraction (SFE) (Garcia-Salas et al., 2010), among others. The objective of this paper was to evaluate the obtention of bioactive compounds from different fruit residues with the aim of analyzing their economic viability using non-conventional technologies such as SFE.

The methodology used to achieve this objective was divided into three parts: **(i)** conceptual design, **(ii)** process simulation and **(iii)** economic analysis. Five fruit residues were selected for analysis: mango peel, yellow passion fruit seed, raspberry seeds, mandarin peel and açaí berry.

The ***first stage*** (i.e., conceptual design) consisted of designing each of the extraction processes for each fruit using supercritical fluids as the technology to be evaluated. Each design was composed of three main stages: the conditioning of the raw material, extraction and subsequent purification of the bioactive compound obtained for each waste. The ***second stage*** (i.e., process simulation) was performed using Aspen Plus v9.0 software as the main simulation tool. For the modeling of the liquid phase, the thermodynamic model NRTL (Non Random Two Liquids) was used, for the liquid phase the Hayden O'Conell equation (HOC) was used. For each of the scenarios an avocado waste stream of 10 tonne/h was selected. The ***third stage*** (i.e., scenario comparison) was based on the use of economic analyses as the main comparative tool. The Aspen Process Economic Analyzer (APEA) software is the tool used to perform these analyses. The sizing of each of the process equipment was based on the use of the mass and energy balances obtained in the second stage (simulation). The economic analysis considered the costs associated with raw materials and reagents, labor costs and costs associated with the utilities of the process. The depreciation was calculated by the straight-line method considering an operation time of 8000 hours per year. Additionally, the tax rate and interest rate employed in the economic calculations was 17% and 25%, respectively reported by (Serna-Loaiza et al., 2018). Several factors were analyzed in the economic analysis of each of the residues, such as: the minimum scale of processing, the sensitivity to the price of the bioactive compound in the market, sensitivity to the cost of acquisition of the raw material and the dependence on the use of the fuel (influence of the use of diesel or residual biomass as fuel)

Conclusion.

It was demonstrated that economic viability depends mainly on the characteristics of the antioxidant obtained in each case and that this in itself defines the sales price. However, two predominant factors were decisive: the overall efficiency of utilization of the whole residue and the total yield of extracts that can be obtained from each residue.

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