CITRUS PROCESSING WASTEWATER-BASED BIOREFINERY FOR PRODUCTION OF HIGH-ADDED VALUE COMMODITIES

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ABSTRACT

Citrus processing industry (CPI) for juice and concentrate constitutes one of the largest fruit processing sub-sectors generating increasing quantities of underutilized side-streams. The worldwide industrial generation of citrus peel waste exceeds 23 x 10^6 t per year[1] and mainly consists of peels, pulp, seeds and segment membranes[2]. An additional burden of CPIs concerns the significant amounts of wastewater disposed, which constitute up to 17 m^3 per t of processed fruit[3], depending on the process and the water management in the production plant. The industrial effluents that occur mainly constitute water used for factory cleaning, heating and cooling and water produced by essential oils extraction and juice concentration. Citrus processing wastewater (CPWW) is characterized by large variability of organic loads, suspended and settling solids as well as soluble or insoluble compounds, such as sugars, bioactive compounds and organic acids[4]. Specifically, CPWW resulting from the recovery of essential oils by citrus pomace and processing water centrifugation contains up to 73.6 g L^{-1} total sugars, 1.4 g L^{-1} polyphenols (Gallic Acid Equivalents), 196.4 mg L^{-1} of d-limonene and 6% of total solids, which are rich in bioactive compounds such as carotenoids and fibre content (celluloce, hemicellulose). Previous studies have mainly focused on the valorization of CPWW aiming to reduce the chemical oxygen demand through pectin extraction using ethanol precipitation[5]. Anaerobic digestion for methane[6] and electrical energy[7] production as well as dark fermentation for bio-hydrogen generation[8] were also studied.

Herein, an integrated biorefinery approach was used for the manufacture of high-added value commodities and the production of bacterial cellulose using the CPWW emitted from the industrial process aimed for the recovery of essential oils. Specifically, the present work focused on polyphenols recovery through adsorption evaluating different types of resins, effluent volumes and flowrates, while a continuous recovery system was developed to assess various solvents for polyphenols desorption. Furthermore, a range of food-grade organic solvents was applied for carotenoids recovery from the solid fraction of the wastewater yielding up to 1.74 mg g^{-1}, while the remaining sugar-rich wastewater was employed in microbial fermentations for bacterial cellulose production achieving the manufacture of up to 6.5 g L^{-1} of biopolymer.

KEYWORDS: Citrus processing wastewater, biorefinery, adsorption, bioactive compounds, bacterial cellulose

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