A HOLISTIC CITRUS PROCESSING WASTE-BASED BIOREFINERY FOR ADVANCED MANUFACTURE OF EXTRACTABLES AND BACTERIAL CELLULOSE

P. Karanicola[1,2], M. Patsalou[1], F. Pyrilli[1], P. Christou[2], G. Panagiotou[2], M. Koutinas[1,*]

[1]Department of Chemical Engineering, Cyprus University of Technology, Limassol, Cyprus

[2]KEAN Soft Drinks Ltd, Limassol, Cyprus

*(*michail.koutinas@cut.ac.cy)*

ABSTRACT

Citrus processing industry (CPI) generates substantial amounts of by-products given that only 50% of the fruit's mass is used during the production process. More than 24 x 10^6 t of citrus peel waste (CPW) are generated during industrial processing, which mainly consists of peels, segment membranes, seeds and pulp. Processing 1 t of citrus fruit could generate 1 – 17 m^3 of citrus processing wastewater (CPWW) depending on the processes used in the plant, which mainly include juice concentration, essential oils (EO) isolation and factory cleaning. CPWW generated through the EO isolation process constitute 57 g L^{-1} sugars, 1.3 g L^{-1} polyphenols, 450.7 mg L^{-1} EO and 0.6% (w/v) solid residues. Bacterial cellulose (BC) constitutes a biopolymer of high industrial importance owing to numerus unique properties including high purity, high crystallinity, biodegradability and enhanced mechanical strength [2]. An ultrasound assisted dilute acid hydrolysis (UADAH) system has been previously developed for CPW treatment isolating EO and pectin as well as a sugar-rich hydrolysate applicable in BC fermentations[3]. Herein, a holistic biorefinery was developed incorporating mixtures of CPW and CPWW in the UADAH process employing optimal processing conditions determined with the use of a statistical model aiming to maximize the process' yield. The resulting rich in polyphenols and sugars hydrolysate was treated using adsorption resins for polyphenols recovery, while the sugar-rich hydrolysate was applied in BC fermentations via use of *Komagataebacter sucrofermentans* DSM 15973 as cellulose producer. Thus, incorporating CPWW in the UADAH process resulted in the production of 4.75 mg_{EO} g_{db}^{-1}, 0.49 g_{pectin} g_{db}^{-1} and 0.31 g_{sugars} g_{db}^{-1}, while 68% of the initial polyphenols content was isolated through adsorption/desorption. The sugar-rich hydrolysate formed was employed in BC fermentations resulting in the production 6.5 g L^{-1} BC and a corresponding yield of 8.4 g_{BC} per 100 g_{CPW}. The study has shown that UADAH could maximize pectin production, while by controlling fermentation conditions in terms of carbon to free amino nitrogen ratio could enable adjusting the properties of bacterial cellulose for certain industrial applications.

KEYWORDS: Citrus processing waste, ultrasound-assisted dilute acid hydrolysis, polyphenols, bacterial cellulose, pectin

REFERENCES

[1] Patsalou, M., Chrysargyris, A., Tzortzakis, N., Koutinas, M. (2020). *Waste Management* 113, 469-477.

[2] Hussain, Z., Sajjad, W., Khan, T., Wahid, F. (2019). *Cellulose*, 26(5), 2895-2911.

[3] Karanicola, P., Patsalou, M., Stergiou, P.-Y., Kavallieratou, A., Evripidou, N., Christou, P., Panagiotou, G., Damianou, C., Papamichael, E.M., Koutinas, M., 2021. *Bioresour. Technol.* 342, 126010.