TECHNO-ECONOMIC EVALUATION AND LIFE CYCLE ASSESSMENT OF POLY(3-HYDROXYBUTYRATE) PRODUCTION THROUGH A BIOREFINERY OF FRUIT WASTES

D. Ladakis[1], O. Psaki[1], S.M. Ioannidou[1], I.K. Kookos[2], A. Koutinas[1]*

[1] Iera Odos 75, 11855, Athens, Greece, Department of Food Science and Human Nutrition, Agricultural University of Athens
[2] University of Patras, 26504, Rio, Greece, Department of Chemical Engineering
* akoutinas@aua.gr

ABSTRACT

The high production cost of poly(3-hydroxybutyrate) (PHB) is the bottleneck for industrial implementation [1,2]. This study focuses on biorefinery development and sustainability analysis of fruit waste valorisation into value-added fractions and fermentation feedstock for PHB production. Three different fruits were studied (pears, apples, and peaches). Free sugars were initially extracted under different solid-to-liquid ratios (1:10, 1:15, 1:20) at 40°C to be utilized for PHB production. The extraction of phenolic compounds and pectin at different solid-to-liquid ratios (1:10, 1:20, 1:30 w/v) using 70% acidified aqueous solution and different acids (hydrochloric acid, nitric acid, and citric acid) were evaluated. PHB production was carried out with the bacterial strain *Burkholderia sacchari* DSM 17165 using free sugars from fruits. Fed-batch bioreactor cultures lead to more than 60 g/L PHB, 0.32 g/g yield and 1 g/(L·h) productivity. The whole biorefinery process was designed using the software UniSim (Honeywell). The fixed capital investment and the cost of manufacture were estimated at different plant capacities. A discounted cash flow analysis has been carried out to estimate the minimum selling price (MSP) of PHB. The optimal plant capacity (OPC), the discounted payback period (DPP), and the Net Present Value (NPV) have been also estimated. The OPC for the PHB with the proposed bioprocess was estimated at 50 kt/year, while the MSP was $3.8-5.2/kg (considering different selling prices for by-products). The Global Warming Potential and Abiotic Depletion Potential of PHB production were estimated at 1.47 kg CO_2-eq per kg PHB and 45 MJ per kg PHB, respectively.

KEYWORDS: PHB, Biorefinery, Process design, Life Cycle Assessment, Techno-economic evaluation

REFERENCES

[1] Kennedy, M., List, D., Lu, Y., Foo, L. Y., Newman, R. H., Sims, I. M., ... & Fenton, G. (1999). *Analysis of plant waste materials* (pp. 75-119). Springer, Berlin, Heidelberg.

[1] Taylor, T., & Hood, W. (2020). *J. Comp. Mech.* 87 (20): 2200-2245.

ACKNOWLEDGMENTS

We acknowledge support of this work by the project “Bioconversion of Food Industry Wastes to Biopolymers for Packaging Applications-Waste to Biopolymers” (MIS 5030731) which is funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).