Assessing the Industrial Eco-efficiency of Pea Protein Extraction by the Hybrid Fractionation Method through a Techno-eco-environmental Analysis

ALLOTEY D. (1), KWOFIE E. (1), ADEWALE P. (2), LAM E. (3), NGADI M. (1)

1 McGill University, MacDonald Campus, Sainte-Anne-de-Bellevue, Canada

2 National Research Council Canada, Bioprocessing and Biocatalysis Team, Aquatic and Crop Resource Development Research Centre, Ottawa, Canada

3 National Research Council Canada, Bioprocessing and Biocatalysis Team, Aquatic and Crop Resource Development Research Centre, Montreal, Canada

Global plant-protein demand is dramatically increasing, which has informed the need to expedite protein production towards enhancing plant-protein supply, with peas being the most exploited plant protein source due to their large production market. Aside from the present dry and wet fractionation process currently adopted, there is the hybrid fractionation method, a newly evolving method that has been proven sustainable and produces high-quality protein isolates (75-85%). However, little effort has been made to assess the economic and environmental implications of upscaling and economy-wide adoption of the hybrid fractionation method. This study uses the superstructure approach to explore candidate hybrid fractionation configurations (HFC). The superstructure design of HFCs was based on different combinations of wet and dry methods and varying pre-treatment and pre-classification methods. Wet and dry methods consisted of milling, extraction, centrifugation, precipitation and drying. The performances of the selected HFC scenarios were evaluated using an integrated Life Cycle Assessment-Techno-Economic Assessment (LCA-TEA) environment. First, the HFC scenarios were simulated in SuperPro Design software to carry out the material and energy balances and assess their technical and economic efficiencies. This was followed by an environmental LCA using OpenLCA v1.11. Finally, the results were integrated to exploit the inherent LCA-TEA trade-offs using Data Envelopment Analysis. The proposed approach allows for a more accurate sustainability comparison for different HFCs. In addition, sensitivity and uncertainty analyses were carried out to assess the critical parameters of the most significant influence. The results provide invaluable insights into the technical, economic, and environmental trade-offs to permit more informed decisions on the industrial adoption of the optimal HFC for sustainable pea-protein extraction. Going forward, the findings from this analysis would be critical for stakeholders, including industrial pea protein processors, protein extraction researchers and policymakers