



## Techno-economic evaluation of pectin production from apple pomace

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### Abstract

The production of pectin from apple pomace offers an opportunity for industrial use and waste valorization. The optimization of the extraction process and assessment of its economic viability are the main objectives of this study. The extraction process was conducted according to Box-Behnken experimental design including pH, temperature, and time as extraction variables. Their individual and interaction effects on pectin yield were assessed by Response Surface Methodology (RSM). Based on the experimental data, an industrial-scale process simulation was implemented in the context of SuperPro Design software under the assumption of ideal operation conditions for all unit processes. The highest pectin yield was achieved as 9.5% under optimal conditions (pH 1.1, 90 °C, 2.5 hours). The developed model was statistically significant and demonstrated a strong fit to the experimental data ( $R^2 = 0.9605$ , Adjusted  $R^2 = 0.9097$ ). Industrial-scale simulation at a processing capacity of 10,000 kg/h indicated an annual net profit of approximately \$7.99 million and a unit production cost of \$16.1/kg. Economic indicators were calculated as ROI = 13.3%, payback period = 7.5 years, IRR = 13%, and NPV = \$24.6 million. The results confirm that pectin production from apple pomace is both technically viable and economically feasible. Furthermore, integrating by-product utilization strategies can further enhance overall profitability.

**Key Words:** Apple Pomace Valorization, Pectin Extraction, Process Simulation, Economic Feasibility

