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Designing a biorefinery for the extraction of high value-added caffeine from tea waste, and its techno-economic evaluation

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Biorefinery is defined as the sustainable refining of biomass into valuable bio-based products. Today there exists an increasing demand for replacing conventional, chemical production methods of high value-added chemicals with biorefinery applications, although the costs are still exceeding the conventional production methods. Turkey is the highest consumer of tea beverage and tea production is almost solely for domestic use. Unfortunately, tea production wastes are not recycled thus giving rise to environmental pollution. Dry tea waste can be estimated to contain 1,75 % caffeine, which is a high value-added chemical used in chemical, pharmaceutical and beverage industries. Decaffeination with hot water was merged with liquid-liquid differential extractions using heptane as a solvent, to construct a process design for caffeine biorefinery in this study. This is the only study to generate a process design that occupies recycles and series configurations with continuous mode of operation utilizing less toxic solvents and recycles them to lower the environmental burden and uses simpler system of leaching extraction followed by liquid-liquid differential extraction with respect to super critical CO₂ extraction, while producing highly favorable techno-economical results. Consequently, the aim of the study was to produce a novel process design for a biomass refinery application utilizing tea wastes to extract high value added chemical, caffeine, while evaluating the process techno-economically. In conclusion, the preliminary cost estimates gave a promising result for such biorefinery application in Turkey with NPV of 17 457 000\$, payback time of 4,41 years, profitability up to 50% of the daily treatment capacity, toleration up to 15% interest rate, profitability above 30\$/kg product selling price, significant sensitivity to selling price of the product, labor cost, steam price and transportation cost, and total capital investment of 27 338 000\$.

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