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Tea Waste Valorization by Solid State Fermentation and Ionic Liquids Extraction Methods

[1]Yigal Achmon, [1]Bixia Qiu, [1]Yuying Zeng and [2]Avi Shpigelman

[1]*Guangdong Technion Israel Institute of Technology, Shantou, China*
[2]*Technion Israel Institute of Technology, Haifa, 3200003, Israel*

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Abstract

Tea, a globally popular beverage, continues to witness increased production worldwide. The forecast indicates a projected annual growth rate of 2.2 percent in black tea production, reaching a staggering 4.4 million tons by 2027. However, the expanding beverage market has led to the accumulation of tea waste, encompassing pruned stems, discarded leaves and buds, as well as remnants left after preparing tea infusion. Consequently, the magnitude of tea waste has become a significant challenge. Nonetheless, this waste contains a plethora of valuable components, including cellulose, hemicellulose, lignin, theanine, proteins, polyphenols, polysaccharides, caffeine, pigments, saponin, vitamins, trace elements, and more. China, in particular, is estimated to generate over 5 million tons of tea waste annually, with only a fraction of it being reused effectively. To address this issue, our research focuses on two innovative methods for utilizing tea waste.

- Solid-state fermentation (SSF) of tea residues: This technique involves aerobic or anaerobic microbial cultivation with a solid-phase concentration exceeding 15% (w/w) of the total weight. SSF shows promising potential in generating value-added products from tea waste.
- Ionic Liquid (IL) extraction of tea residues: By employing ILs as solvents, this method enables the extraction of polyphenols and caffeine from tea waste, resulting in higher and more stable yields compared to conventional solvents such as water or 70% ethanol (ETOH).

Our research findings demonstrate the efficacy of both approaches in improving the extraction of active compounds. During the SSF process, caffeine content exhibited significant growth in all fermentation systems, with the highest increase observed in green tea waste (59%), followed by the mixture (48%). Coffee waste demonstrated a 32% increase, while black tea waste exhibited a modest growth of 22%. Furthermore, the

respiration rates of the fermentation systems indicated that microbial activity was highest in green tea waste. Notably, the top three volatile organic compounds identified by their mass-to-charge ratio (m/z) in the principal component analysis (PCA) could serve as indicators for different stages of fermentation. Additionally, fermentation led to alterations in the bacterial community structure, with only green tea waste showing an increase in α diversity. In the IL extraction study, the use of ILs proved superior in extracting tea polyphenols and caffeine compared to water and 70% ethanol. This underscores the potential of ILs as effective solvents for extracting bioactive compounds from tea waste. Apart from extraction efficiency, the study also monitored the generation of volatile organic compounds (VOCs) during the extraction process. Notably, the accumulation of VOCs with m/z values of 43 and 61, representing compounds like oxirene, diazomethane, propylene, dioxohydrazine, carbon trioxide, or acetic acid, may serve as indicators for estimating the quantity of extracted substances over time. This research signifies that alternative pathways, such as SSF and IL extraction, hold promise for valorizing tea waste and offer a potential direction for improving tea waste management.

Keywords: Tea waste, solid state fermentation, ionic liquid extraction, volatile organic compounds, caffeine

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