

VALORISATION OF OKRA AND CITRUS WASTE FOR CELLULOSE EXTRACTION AND NANOCELLULOSE SYNTHESIS TOWARD SUSTAINABLE POST-HARVEST WASTE MANAGEMENT IN SRI LANKA

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Sri Lanka generates approximately 270,000 metric tons (MT) of fruit and vegetable waste annually, primarily due to post-harvest losses accounting for 30 – 40% of total production. This study explored strategies to valorise such waste in economic centers. As high-crystalline, high-purity cellulose was increasingly valued across industries, cellulose yield from commonly discarded products was investigated. A market survey identified 15 frequently discarded fruits and vegetables for analysis. For cellulose extraction, defatted sample powders were subjected to sequential pre-treatments involving acid hydrolysis (1.0 mol L⁻¹ and 0.5 mol L⁻¹ HCl), delignification (1.0 mol L⁻¹ NaOH), and bleaching (1.5% NaOCl, 95 °C), and the final products were freeze-dried. Fourier transform infrared (FTIR) spectroscopic analysis confirmed cellulose by characteristic bands of O–H stretching (~3330 cm⁻¹), C–H stretching (~2900 cm⁻¹), and β-(1→4)-glycosidic linkages (~895 cm⁻¹). Okra (*Abelmoschus esculentus*) yielded the highest cellulose content (28.58±2.24%), followed by citrus (*Citrus aurantium*) peel (23.31±2.87%), cucumber (*Cucumis sativus L.*) peel (17.36±2.24%), luffa (*Luffa acutangula L.*) peel (14.59±3.21%), and avocado (*Persea americana Mill.*) peel (12.13±0.33%). Okra and citrus were identified as the most promising sources. Based on national production and waste estimates, valorisation of okra waste (~28,134 MT year⁻¹) could yield ~1,407 MT of cellulose, while citrus peel by-products (~79,932 MT year⁻¹), considering peel fractions of ~40% for sour orange and ~20% for lime, could yield ~3,726 MT cellulose, offering a combined recovery of ~5,133 MT cellulose annually. Nanocellulose is important for its high mechanical strength, large surface area, and biodegradability, enabling applications in food, packaging, biomedical, and composite industries. Therefore, nanocellulose synthesis was explored via sulfuric acid hydrolysis (58% w/w, 65 °C, 3 h, 1:40 cellulose-to-acid ratio). The sedimented suspension (18 °C, 24 h) was ultrasonicated (75%, 10 min), and nanocellulose was separated and confirmed by field emission scanning electron microscopy. This study confirms the feasibility of extracting cellulose and synthesising nanocellulose from agro-waste, supporting sustainability and circular bioeconomy initiatives in Sri Lanka.

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