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Current scenario and global perspectives of citrus fruit waste as a valuable resource for the development of food packaging film

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ABSTRACT

Background: Citrus fruits are the most prevalent fruit crops around the world. The general consumption of citrus fruits and their processing to finished products like juices, jam, and jelly generate a huge amount of waste (peel, pomace, and seeds). This waste has triggered concerns about the environment, health, and economic losses. Conversely, petroleum-based plastics are highly resistant to degradation and sustain in the environment for a prolonged period resulting in easy access of microplastics into human food chain caused majorly due to plastic food packaging. Living organisms can accumulate microplastics in cells and tissues which results in threats of chronic biological effects and potential health hazards for humans.

Scope and approach: For sustainable mitigation, citrus fruit processing wastes (CFPW) is explored as one of the prominent bioresources for biopolymers like pectin, cellulose, hemicellulose, lignin, and bioactive compounds having strong antioxidant and antimicrobial properties. The review provides a comprehensive overview of CFPW utilization for developing biodegradable packaging film for its applicability in food products. The review encompasses both the direct incorporation of citrus peel powder and the secondary utilization of beneficial substances from these residues, mainly pectin, essential oils, and seed extracts.

Key findings and conclusion: This review gives insight into the compounds that support the implication of CFPW in packaging with the concept of circular economy, sustainability, and zero waste. An attempt has been made to reflect the role of various components found in CFPW towards its applicability in food packaging with the strategy of comprehensive utilization in the most suitable way.

1. Introduction

Citrus fruits belong to the Rutaceae family. These are one of the most produced fruits worldwide in the Southern as well as Northern Hemispheres. The key aspect of huge production is its exceptional sensory properties (flavor, taste, and odor) and nutritional quality (Suri et al., 2022). This has taken the interest of farmers worldwide for its production in the last few decades. In the year 2019, around 143.48 million tons of annual production was recorded. The major cultivated citrus fruit species were orange (*Citrus sinensis*), mandarin (*Citrus reticulata*), grapefruit (*Citrus paradise*), and lemon (*Citrus limon*). Owing to such great market demand, nearly ninety citrus-producing countries have increased their production volumes (Nieto et al., 2021). China is the leading citrus-producing country with a production rate of 38.19 million tons, after which 19.65 million tons is produced by Brazil, 12.99 million

tons by India, 8.41 million tons by Mexico, 7.25 million tons by the United and last 6 million tons by Spain (Nieto et al., 2021). Among all Orange is the major citrus fruit variety which contributes around 54.84% of the total citrus fruit production in the world. Followed by mandarin with 24.70%, 20.44% of lemon/lime, and 6.47% of grapefruit.

At present, citrus fruit production has far exceeded its demand which consequently generates a great volume of citrus fruit waste. Approximately around 10 million MT of citrus fruit processing waste is generated each year worldwide creating a somber environmental issue (FAO, 2021; Zema et al., 2018). As per the estimation, around 40% of citrus fruits cultivated in the world are utilized by the juice processing industries only, thus acting as a major source of citrus fruit waste producer (Russo et al., 2021). Other processing industries utilizing citrus fruits for producing products like, jams, jellies, canned products, and flavouring agent also generates citrus fruit waste in the form of peel,

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