

TRANSFORMING CITRUS PEEL WASTE: INNOVATIVE GREEN EXTRACTION AND MULTI-FUNCTIONAL APPLICATIONS OF PECTIN AND ESSENTIAL OILS

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INTRODUCTION

Citrus peel waste is a rich source of bioactive compounds, including pectin and essential oils, with potential for functional foods, preservatives, and therapeutics. This study highlights innovative green extraction methods to transform these byproducts into value-added products, promoting sustainability in the citrus industry.

OBJECTIVE

- Evaluate the effectiveness of green extraction methods for obtaining bioactive compounds from citrus peel waste
- Evaluate biological properties for multi-functional applications



Peel	Essential oils	Pectin	Ref.
Bitter orange (<i>Citrus aurantium</i>)	<ul style="list-style-type: none"> • Green approach for multivariate consecutive extraction process • High yields of essential oils (0.81%) was obtained • 42 kinds of main components of essential oils were identified 	<ul style="list-style-type: none"> • Ultrasound-assisted extraction of bitter orange peel pectin was optimized. • The obtained pectin had a good emulsifying and antioxidant activity. 	[6],[7]
Sweet Oranges (<i>Citrus sinensis</i>)	<ul style="list-style-type: none"> • Extraction: Microwave assisted hydrodistillation • D-limonene was the most abundant essential oils • Y-terpinene and Trans α-bergamotene were also detected 	<ul style="list-style-type: none"> • Pectin yield from navel orange peels increases with ultrasonic power amplitude. 	[1],[4]
Grapefruits (<i>Citrus paradisi</i>)	<ul style="list-style-type: none"> • Extraction: Microwave assisted hydrodistillation • 89.2% Limonene • 2.40% essential oil on a dry weight basis 	<ul style="list-style-type: none"> • Heating and ultrasound showed a synergistic effect on pectin extraction. 	[1],[5]
Lemon (<i>Citrus limon</i>)	<ul style="list-style-type: none"> • Extraction: supercritical CO₂ extraction • Limonene was the major component • Other major essential oils: β-Pinene and γ-Terpinene 	<ul style="list-style-type: none"> • Microwave heat was used in an eco-friendly extraction of pectin lemon peel. 	[8]
Lime (<i>Citrus aurantifolia</i>)	<ul style="list-style-type: none"> • Extraction: solvent free microwave extraction • A total of 49 compounds were identified, with limonene content (43.47%) being the highest among all sweet lime peel oil compounds. 	<ul style="list-style-type: none"> • Pressure-induced enzymatic treatment for sustainable pectin production is proposed • Pressure tuning of cellulase and xylanase improves yield and quality of pectin. 	[9]

Table 1. Experiments on extraction of bioactives from citrus peel using different extraction methods

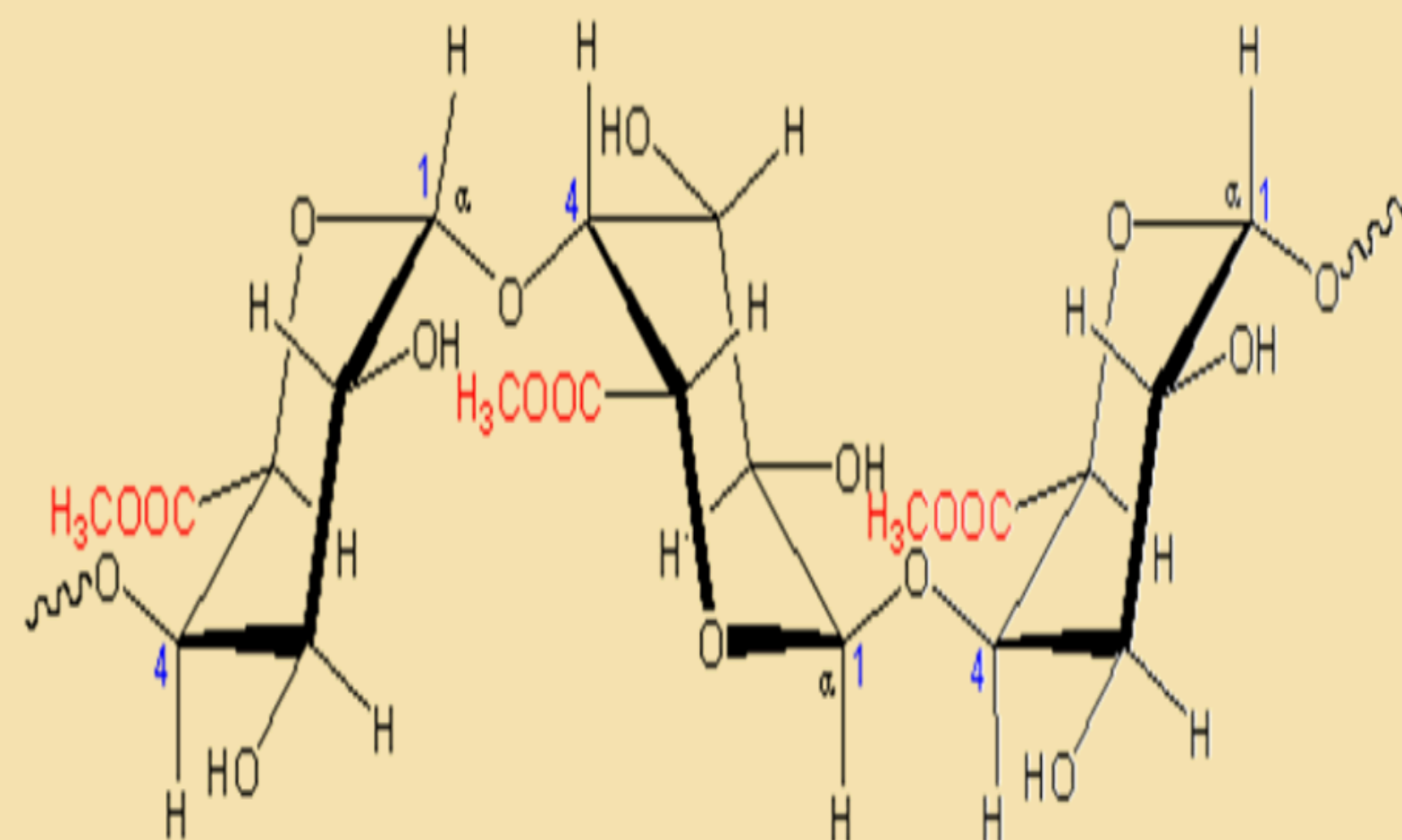
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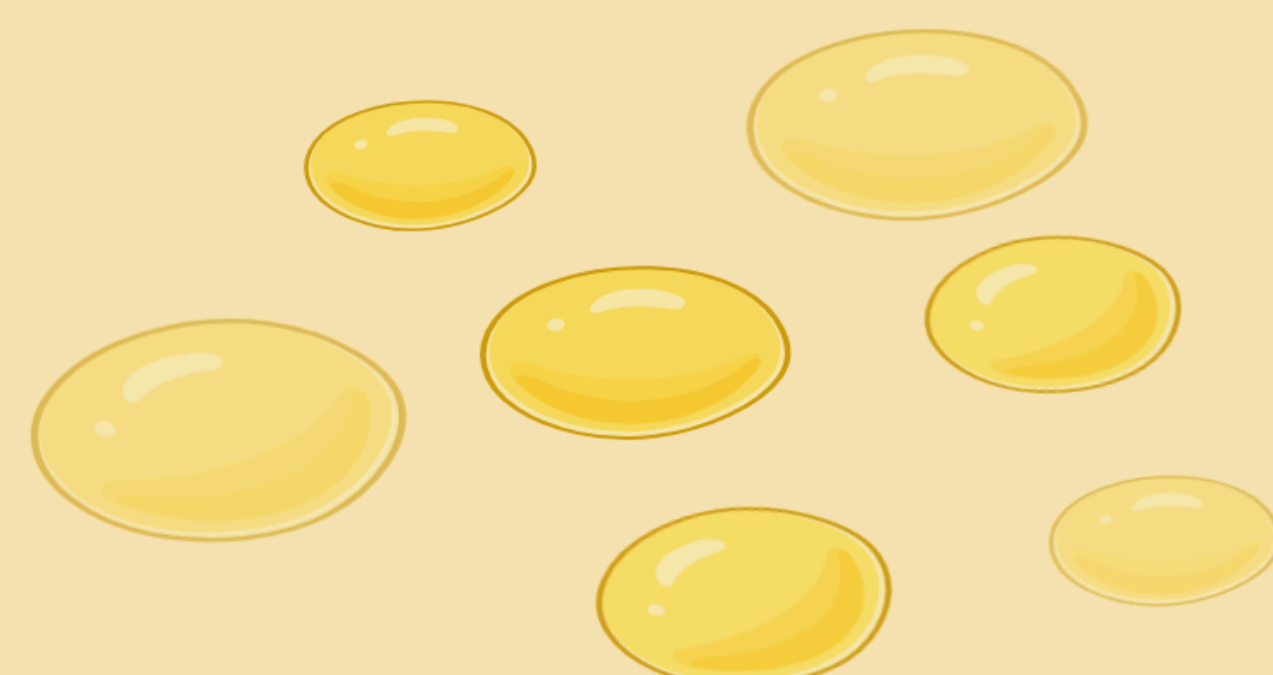
Citrus fruits



Peels



Pectin



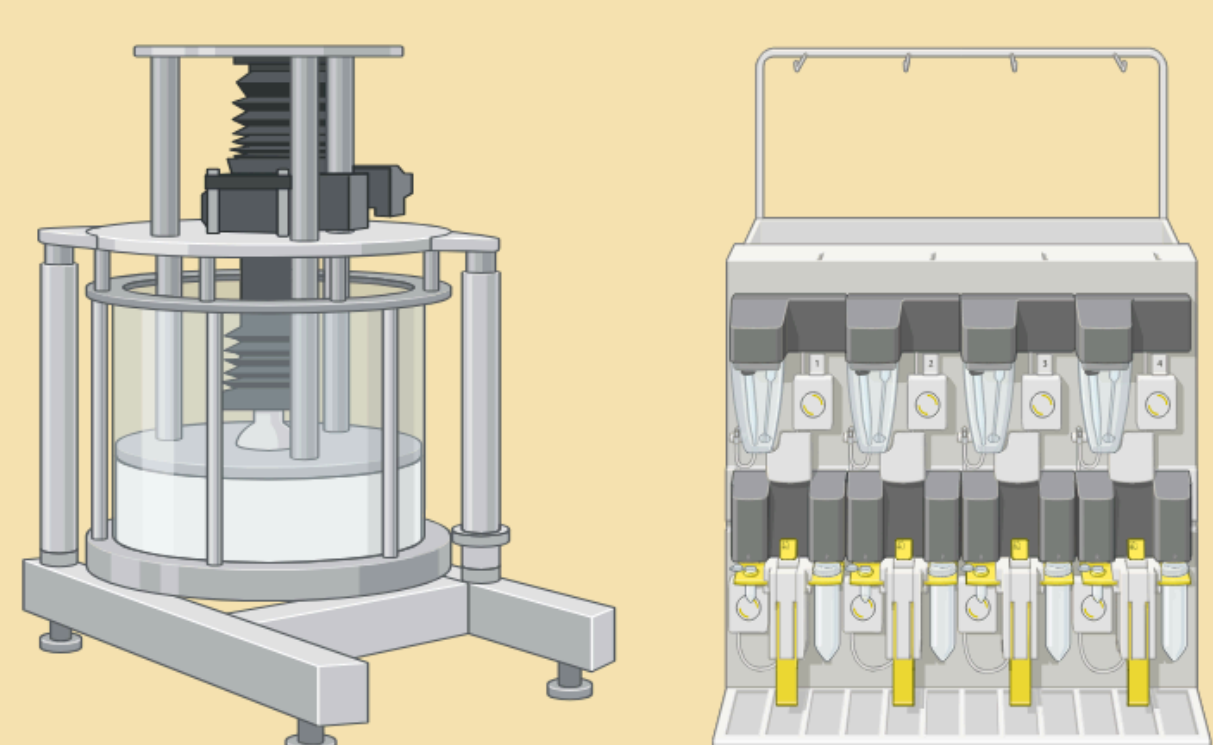
Essential Oils

Green extraction techniques

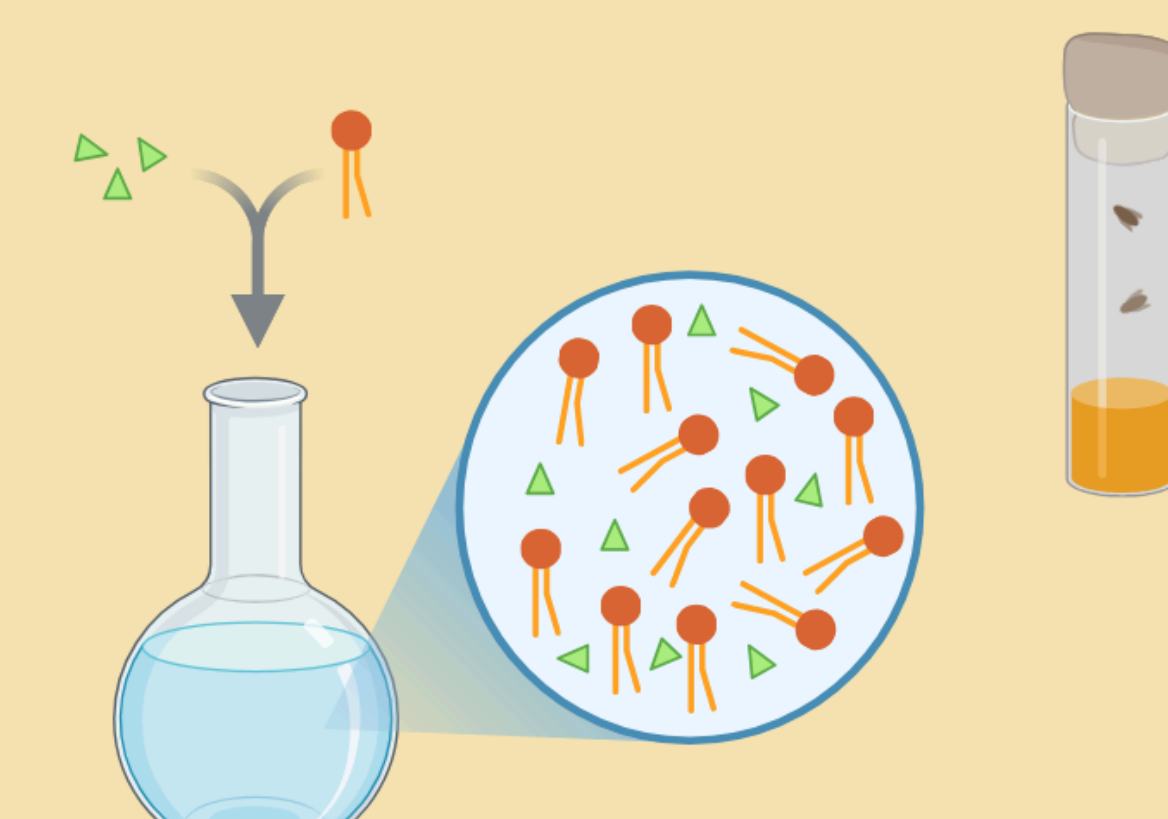


Multi-Functional Applications

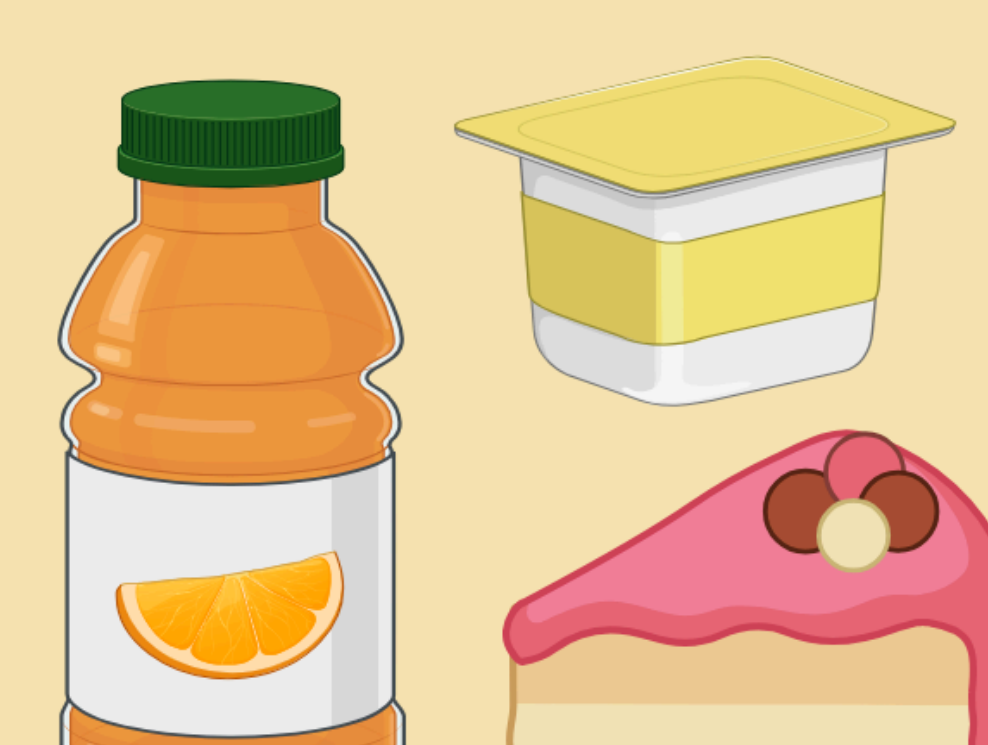
Industrial applications



Therapeutic agents



Functional foods



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Figure 1. Citrus peels as a source of pectin and essential oils for their applications in functional foods, therapeutic agents, and other industrial applications.