

Advances in Food Process Engineering

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PREFACE

Food Process Engineering has witnessed remarkable transformations in recent decades, driven by the urgent need for sustainable technologies, effective waste valorization, and the growing consumer demand for natural, safe, and functional food products. The book “Advances in Food Process Engineering” is a compilation of recent innovations, emerging techniques, and interdisciplinary research in the domain, particularly focusing on bio-based materials, novel extraction techniques, and food preservation strategies.

This volume brings together eight carefully selected chapters that reflect the dynamic evolution of food process engineering. Each chapter is grounded in experimental work and offers insights into practical applications that contribute to enhanced food quality, safety, sustainability, and nutritional functionality. From the application of sodium alginate and kadam leaf extract coatings to extend the shelf life of cape gooseberry, to microwave-assisted protein extraction from mustard meal, the book explores cutting-edge research and development across diverse food matrices.

In particular, this book emphasizes the utilization of agro-industrial by-products, such as lemon waste, pineapple peel, coconut shell, and mustard meal, highlighting their potential to be transformed into valuable food additives, packaging materials, and bioactive compounds. It also introduces readers to eco-leather as a secondary packaging material, biodegradable films, and microencapsulation techniques, reflecting the growing trend toward green technologies and circular economy principles in food systems.

The intended audience includes food scientists, process engineers, researchers, graduate students, and industry professionals who are interested in sustainable innovation and novel applications in food processing. We hope this compilation will serve as both a reference and inspiration for ongoing research and industrial applications.

We extend our heartfelt gratitude to the contributing authors for their valuable research and to all those who supported the creation of this volume. It is our sincere belief that this book will contribute meaningfully to the growing body of knowledge in food process engineering and foster new ideas for future innovations.

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Chapter – 3

Sodium Alginate and Lemon (Citrus Limon) Waste-Based Biodegradable Film

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Abstract

The aim of the study was to develop a biodegradable packaging film using sodium alginate and waste lemon peel. For this purpose, different concentration of both sodium alginate and lemon peel powder was taken in ratios Sodium alginate: lemon peel powder:: 0.5:1, 0.5:2, 0.5:3, 0.5:4, 1:1, 1:2, 1:3, 1:4, and 1.5:1, 1.5:2, 1.5:3, 1.5:4 to obtain 12 film specimens. The films were plasticized using glycerol (5% v/v) and crosslinked with a 2% CaCl₂ solution. The films were developed using the solution-casting method. Dried films obtained were visually homogenous, flexible, and without any cracks. The films were analyzed for various physical, mechanical, optical, and light barrier properties. The physicochemical properties of the film were thickness (0.07 ± 0.01 to 0.27 ± 0.01 mm), grammage (246.72 ± 0.35 to 445.78 ± 0.23 g/m²), moisture content ($10.38 \pm 0.31\%$ to $14.14 \pm 0.37\%$), ash content ($3.23 \pm 0.05\%$ to $5.13 \pm 0.04\%$), water solubility ($64.14 \pm 0.07\%$ to $81.91 \pm 0.23\%$), and water absorption ($19.20 \pm 1.18\%$ to $38.54 \pm 1.45\%$). The developed films displayed good mechanical properties with a maximum tensile strength of 6.42 ± 0.02 MPa for sample SA1:LPP1 having sodium alginate: lemon peel ratio of 1:1. Elongation at break

and burst strength ranged from 4.67 ± 0.12 to $15.27 \pm 0.12\%$ and 0.23 ± 0.01 to 0.66 ± 0.02 MPa, respectively. The highest retraction ratio of $98.33 \pm 0.29\%$ was observed in sample SA1:LPP1. Lemon peel had a significant effect on the color values. An increase in its concentration resulted in an increase in the a^* and b^* values and decreased the L^* value. Lemon peel also improved the light barrier properties of the film with transparency ranging from 3.56 ± 0.47 to 7.03 ± 0.09 . The light transmittance decreased with an increase in lemon peel powder which was in accordance with obtained opacity. The films also showed 83.80 to 90.76% biodegradability in a soil burial test. Based on the results, the film sample SA1:LPP1, sodium alginate: lemon peel ratio of 1:1 had better properties as compared to other films. Therefore, the use of lemon peel can serve as a promising source for the development of biodegradable packaging.

Keywords: Lemon peel; Sodium alginate; biodegradable film; tensile strength; food packaging.

1. Introduction

In recent decades, the rapid expansion of global consumerism has led to an alarming surge in plastic waste and environmental degradation. Plastic packaging, which constitutes a significant portion of this waste, poses a severe threat to the ecosystem, marine life, and human health (Kibria et al., 2023). Plastic packaging for food, while widely used and convenient, has several serious drawbacks that have far-reaching repercussions for the environment and human healthy (Jambeck et al., 2015). Certain food-packaging polymers, such as polycarbonate and polyvinyl chloride (PVC), include hazardous compounds like bisphenol A (BPA) and phthalates (Goodman & Peterson, 2014). These chemicals may leach into the food, potentially causing developmental disorders, hormone disruption, and higher cancer risks (Hahladakis et al., 2018). The manufacturing of these plastics necessitates substantial quantities of fossil fuels which leads to resource depletion and a rise in greenhouse gas emissions. This exacerbates climate change and