Exploring the Potential of Pineapple Waste Parts in Agar Film Production:
Characterization and Performance Analysis

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Introduction

- The excessive use of non-biodegradable plastics in food packaging significantly contributes to environmental pollution and resource depletion.
- The use of food processing by-products in developing bioplastics and organic films represents a promising strategy for reducing waste and creating value-added products.
- Pineapple waste, for instance, is rich in fibers and bioactive compounds, making it an ideal candidate for incorporation into biopolymer films.

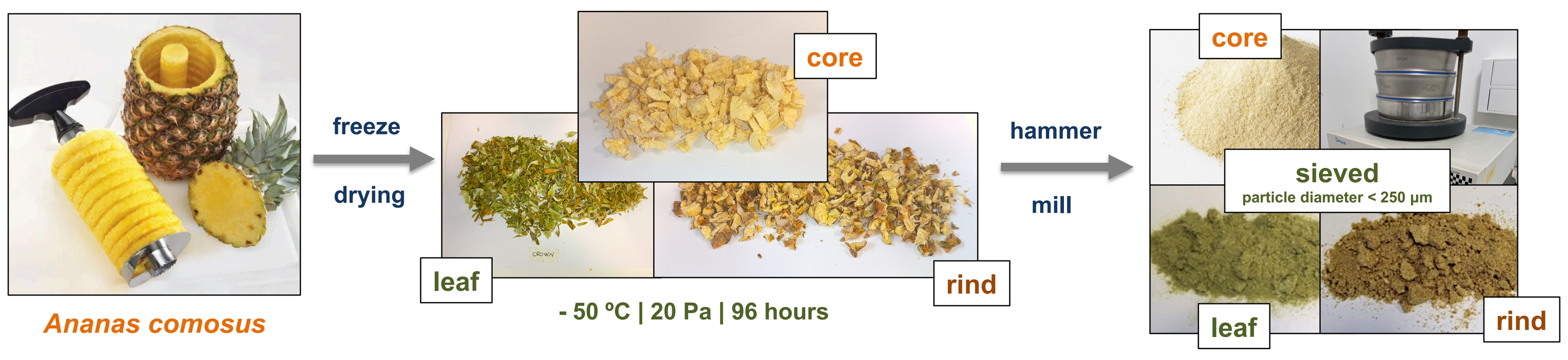
Objectives

- To explore the potential of utilizing pineapple waste parts (core, rind, and leaves) to produce biodegradable packaging films using agar-agar as the primary binding matrix.
- To characterize the films' physical, chemical, and mechanical properties through various tests including colour, thickness, pH, water activity, moisture content, wettability, tensile strength, elongation at break, and Fourier Transform Infrared Spectroscopy (FTIR) analysis for comprehensive comparison.

Materials & Methods

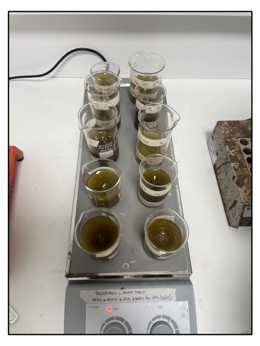
1. Pineapple waste parts

- core, leaf, and rind were removed + cut into small pieces + freeze-dried + micronized



2. Films preparation

- dilution in water of pineapple waste parts + film preparation + casting



I. water + pineapple waste 1% (w/w) | 24 h @ 30 °C | continuous stirring

II. mixture of components @ 100 °C | continuous stirring

Film type	Water (%)	Agar (%)	Pineapple powder (%)	Glycerol (%)
blank	97.78	2.0	0	0.20
core	97.25	1.5	1	0.25
leaf	97.25	1.5	1	0.25
rind	97.25	1.5	1	0.25

% (weight / weight)

III. 20 g of the solutions into petri dishes (diameter of 9 cm) | 20 h @ 35 °C

3. Physico-Chemical characteristics

3 independent samples were tested in all measurements

colour

colourimeter
CR-400, Minolta Co.
CIELab system
Total Colour Difference

$$\sqrt{(L-L_{blank})^2+(a-a_{blank})^2+(b-b_{blank})^2}$$

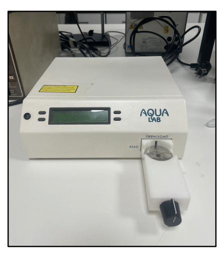
pH

pH meter
sensION+ PH31, Hach-Lange

moisture content

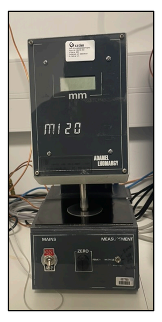
oven
24 hours @ 105 °C

water activity



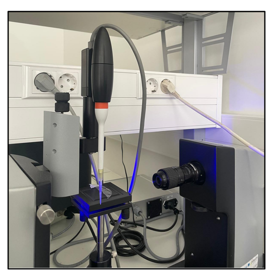
water activity meter
Aqualab–Series 3, Decagon Devices Inc.

thickness



digital micrometer
Adamell MY20

wettability



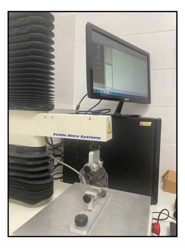
optical contact angle meter
Attension Theta Lite, Biolin Scientific

chemical interactions & composition

PerkinElmer Spectrum BX FTIR System
with a DTGS detector PerkinElmer

4. Mechanical properties

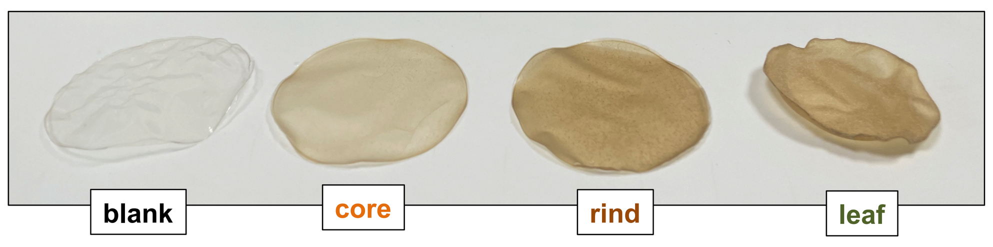
- elongation at break + tensile strength
  - tensile grips 32 mm apart; the cross-sectional area under stress was 5 mm^2 (dimensions under stress 25 mm × 32 mm × 0.2 mm)
  - the break sensitivity was set to 50 g of force
  - films were elongated at a strain rate of 1 $mm.s^{-1}$
  - experiments were performed in triplicate



TA.TX Plus Texture Analyzer
Stable Micro Systems, Ltd.

Results

- **Visual appearance**



- **Thickness**

Thickness was consistent across all films (0.134 ± 0.096 mm), except for leaf-derived ones, significantly thicker (0.322 ± 0.198 mm).

- **Colour**

When pineapple waste was added to the formulations, colour differences increased, especially noticeable in those with leaf powder, resulting in darker and more opaque films.

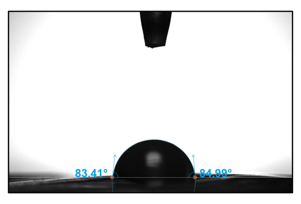
- **pH | water content | water activity**

Films were equivalent in terms of water activity (0.515 ± 0.013) and moisture content (14.86 ± 0.66%). However, there was variation in pH; agar-control (6.75 ± 0.01) and leaf-based films (5.71 ± 0.02) exhibited significantly higher pH values compared to the others (3.73 ± 0.03).

- **Wettability | contact angle**

Film type	Contact angle (º)
blank	79.4 ± 17.2 [bc]
core	67.7 ± 9.0 [b]
leaf	44.3 ± 7.3 [a]
rind	84.1 ± 2.1 [c]

Values are mean ± standard deviation
Different letters indicate significant differences ($p<0.01$; ANOVA + Duncan's test)



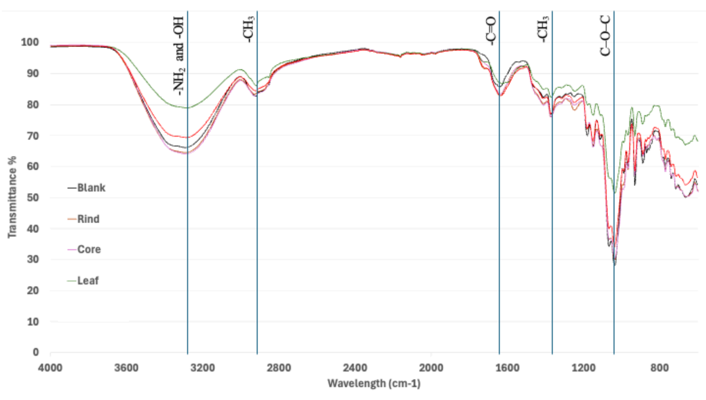
Contact angles lower than 90° indicate surface wettability.

Pineapple rind components enhance hydrophobic properties, while core and leaf components provide hydrophilicity.

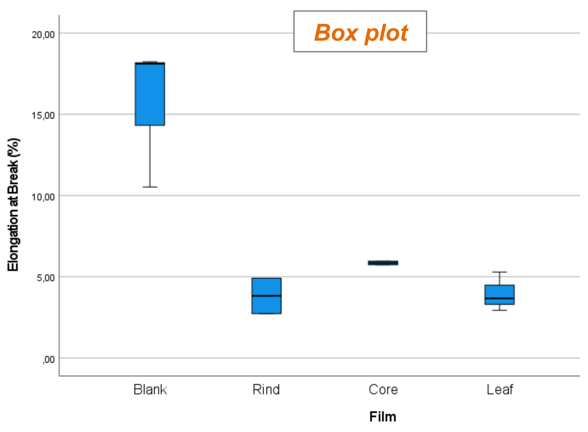
- **FTIR**

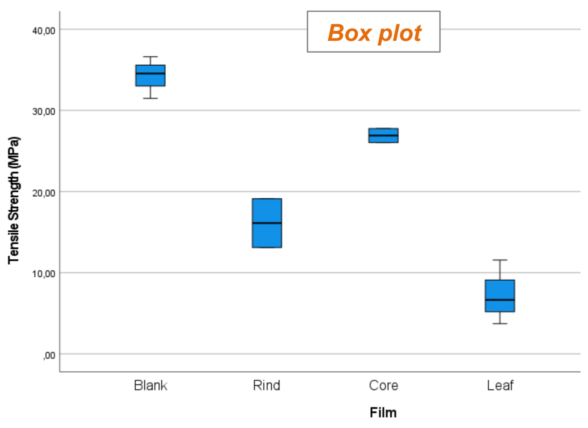
The films incorporating the rind and core follow the FTIR fingerprint of the blank very closely.

The samples with pineapple leaves are different from the rest.



- **Elongation at break & Tensile strength**





Incorporation of pineapple waste parts significantly reduces the mechanical properties of the films.

Main achievements

- Different parts of pineapple waste impart different properties of agar-based films.
- The developed films can be customized for specific applications by adjusting their composition, which allows for enhanced stability. This adaptability lays the groundwork for further optimization to meet targeted needs.
- Future research on water and oxygen permeability should be conducted to fully realize the potential of these films across diverse packaging applications.