Foods 2024 Conference

The 5th International Electronic Conference on Foods

28–30 October 2024 | Online

MDPI

Fabrication of Composite Packaging Films Composed of Apricot (*Prunus armeniaca*) Kernel Protein, Corn Starch and Mint Oil: A Novel Approach

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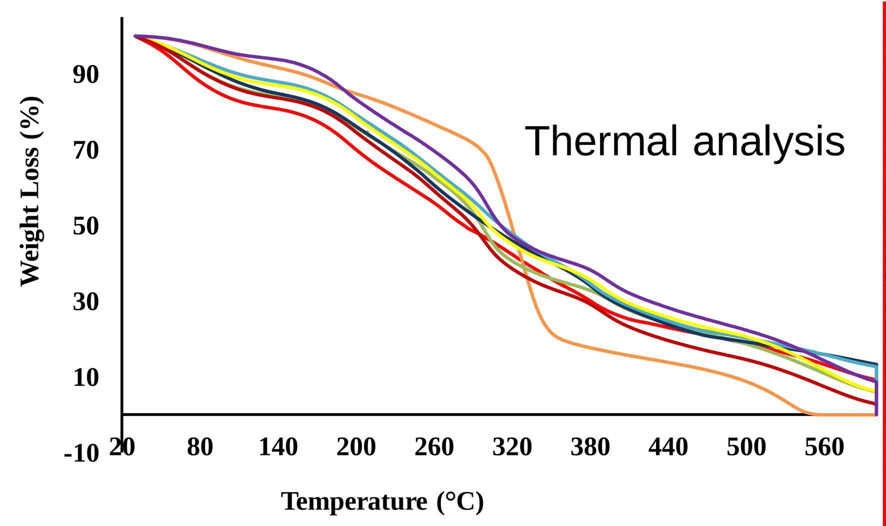
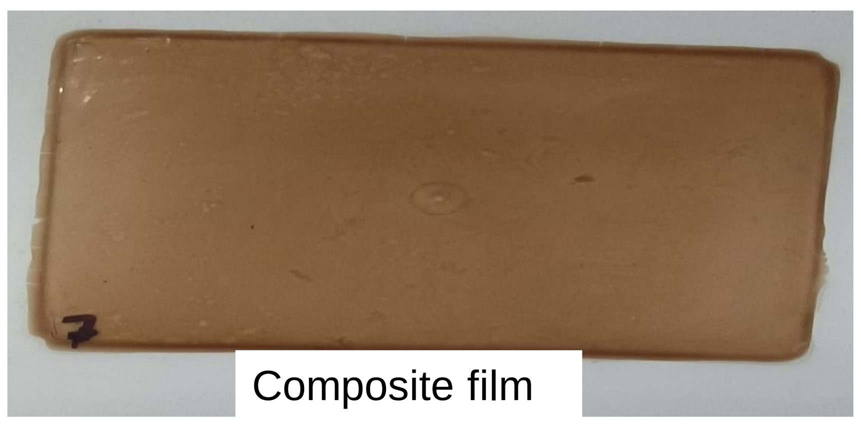
INTRODUCTION & AIM

- Overuse of plastic packaging leads to resource depletion, global warming, and waste.
- Transition towards sustainable and biodegradable packaging alternatives to reduce environmental impact de Oliveira et. al. (2021).
- Plant-based materials reduce fossil fuel dependence and promote a sustainable economy
- Biopolymers like polysaccharides and proteins are abundant, low-cost, and provide strong mechanical propertiesde (Oliveira et al. 2021)
- Underutilized apricot kernels are rich in proteins and lipids, and are ideal for biodegradable packaging
- Apricot kernel proteins are a sustainable option for eco-friendly films
- Composite films by combining proteins and polysaccharides enhances strength and barrier properties in packaging films (Nogueira, et al. 2021).
- Corn Starch is readily available, cost-effective, and forms strong films with excellent gas barrier properties.
- Hydrophobic additives like oils improve water vapor resistance, flexibility, and strength in films (Ochoa, et al., 2020).
- Mint oil provides antimicrobial and barrier properties, making it essential for biodegradable active packaging films.
- This study explores the fabrication of composite packaging films using apricot kernel proteins, mint oil, and corn starch, a combination that has not been previously studied, for potential use in the agro-food industries.

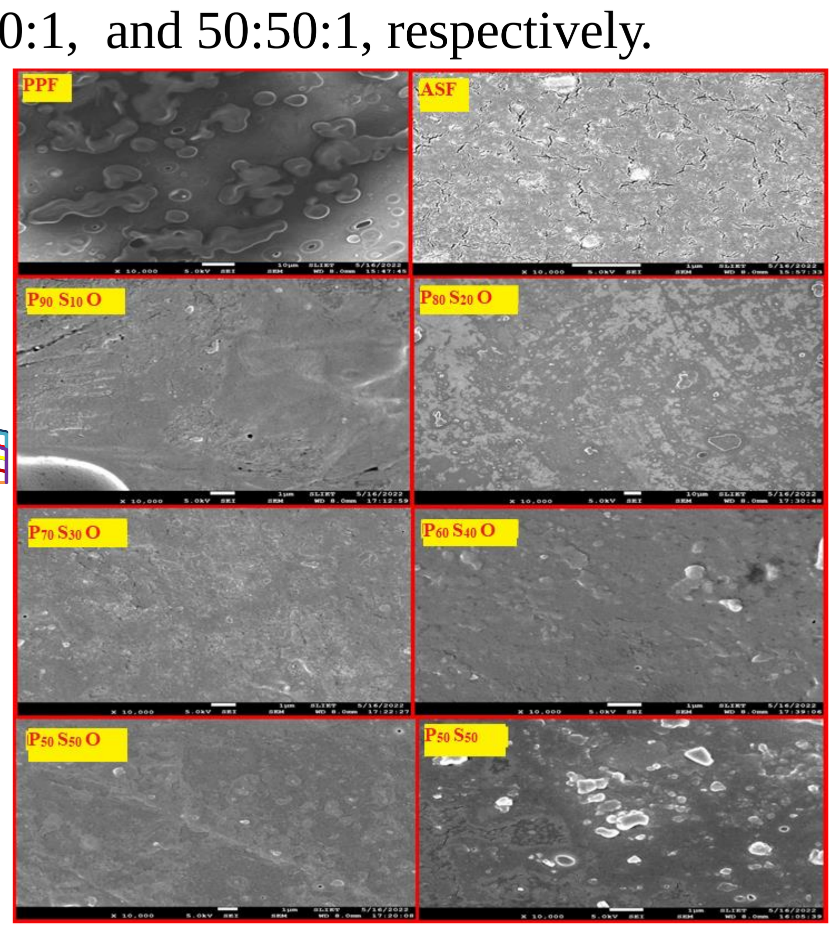
METHOD

Exploration of Film-forming Matrices:
Various composite packaging films were prepared using different ratios of apricot kernel protein isolate, corn starch, and mint oil in the ratios of: 100:0:0, 90:10:1, 80:20:1, 70:30:1, 60:40:1, and 50:50:1, respectively.





Composite film

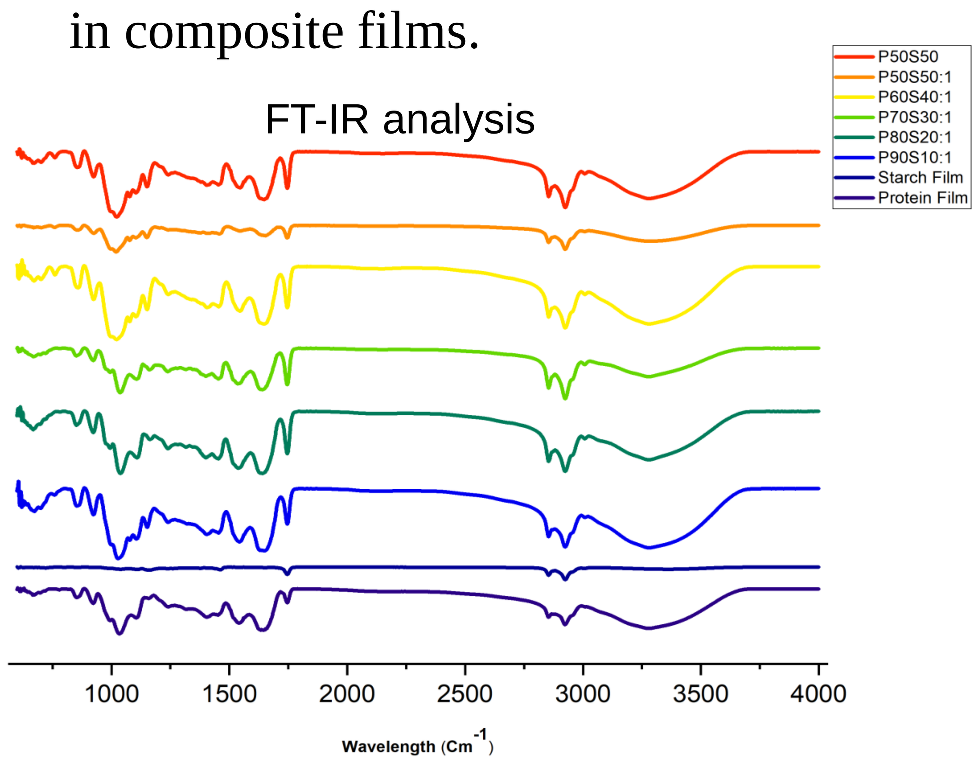


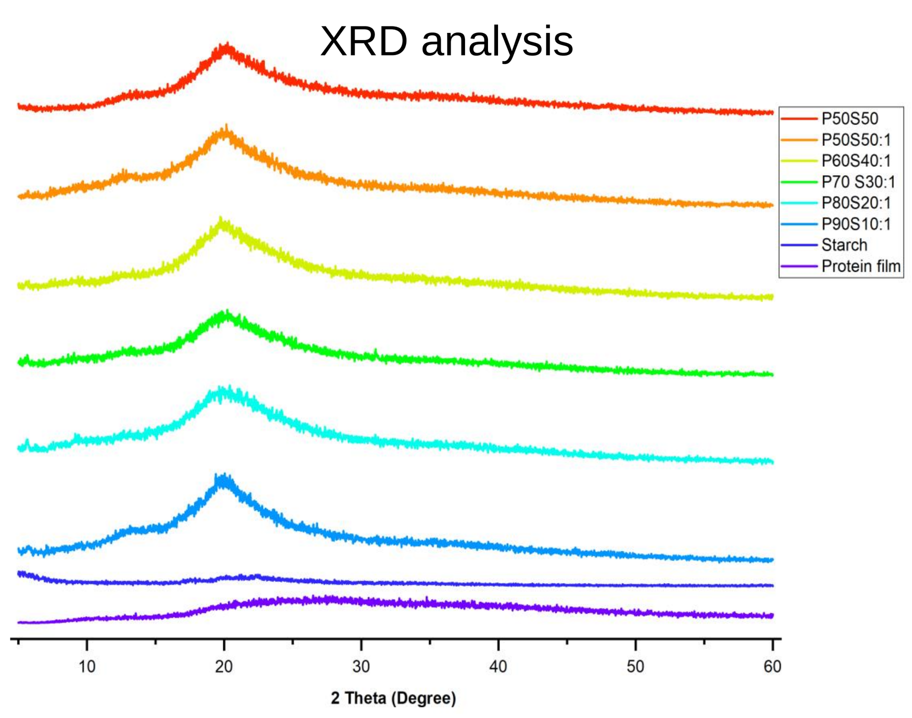
Microstructure analysis

Samples	WVTR $(g/s.m^2) \times 10^{-10}$	Permeance $(g/m^2.\ s.\ Pa) \times 10^{-12}$	WVP $(g\ m^{-1}\ s^{-1}\ Pa^{-1}) \times 10^{-13}$	Tensile strength (MPa)	Elongation at break (%)	Glass transition temperature (Tg)	ΔH (J/g)
Protein	5.04 ± 0.08^{a}	18.07 ± 0.08^{a}	21.07 ± 0.05^{b}	6.9 ± 0.06^{h}	1.21 ± 0.01^{c}	78.19^{h}	67.76^{h}
Starch	4.74 ± 0.11^{b}	16.79 ± 0.07^{b}	22.01 ± 0.06^{a}	12.0 ± 0.08^{a}	0.087 ± 0.01^{d}	104.47^{f}	110.940^{d}
$P_{90}S_{10}O$	4.59 ± 0.03^{d}	16.17 ± 0.03^{c}	19.06 ± 0.01^{c}	7.1 ± 0.03^{g}	1.49 ± 0.02^{b}	87.28^{g}	77.28^{g}
$P_{80}S_{20}O$	4.10 ± 0.07^{e}	14.10 ± 0.02^{e}	15.15 ± 0.03^{e}	7.5 ± 0.01^{f}	1.41 ± 0.02^{b}	118.09^{e}	92.59^{f}
$P_{70}S_{30}O$	3.83 ± 0.09^{f}	12.96 ± 0.06^{f}	13.08 ± 0.02^{g}	7.1 ± 0.03^{d}	1.32 ± 0.05^{b}	146.10^{c}	101.16^{e}
$P_{60}S_{40}O$	3.51 ± 0.06^{g}	11.58 ± 0.05^{g}	13.49 ± 0.01^{f}	8.6 ± 0.01^{c}	1.61 ± 0.02^{a}	149.97^{b}	115.76^{b}
$P_{50}S_{50}O$	3.38 ± 0.11^{h}	11 ± 0.03^{h}	11.67 ± 0.02^{h}	10.4 ± 0.02^{b}	1.63 ± 0.02^{a}	160.42^{a}	123.94^{a}
$P_{50}S_{50}$	4.41 ± 0.04^{c}	10.38 ± 0.04^{d}	17.11 ± 0.03^{d}	7.9 ± 0.01^{e}	1.07 ± 0.06^{c}	145.74^{d}	112.25^{c}

RESULTS & DISCUSSION

- All films prepared from different formulation were self-supporting and peelable.
- Composite film with 50:50 ratio of protein and starch had the highest tensile Strength of (5.72 MPa).
- Lower moisture content and solubility improved the water resistance of the composite films.
- Water activity decreased with increasing starch percentage in composite films.
- Addition of mint oil to composite films formulations improved hydrophobicity by reducing hydroxyl groups.
- Composite film (50:50) was thicker (0.104 mm) than protein (0.099 mm) and starch films (0.102 mm).
- Composite film (50:50) had 30.92% lower water vapor permeability than protein films, indicating better barrier properties.
- Composite film (50:50) was more transparent (20.89%) than protein films
- Increased starch ratio in formulation reduced darkness, with highest ΔE of 5.95 was observed in 50:50 composite films
- Microstructure analysis revealed reduced porosity and increased compactness in composite films with the addition of starch
- Films containing 50% starch had smoother, non-porous morphology with enhanced strength and impermeability.
- Molecular interaction analysis showed stronger protein-starch interactions, fewer OH groups, and tighter chains in composite films.
- FT-IR spectroscopy revealed peak shifts in composite films, suggests enhanced bonding between components.
- X-ray diffraction study showed increased crystallinity in composite films due to amylose-lipid interactions.
- Differential scanning study demonstrated higher melting temperature and enthalpy in in composite films.





CONCLUSION

The study demonstrates that composite films made from a 50:50 ratio of apricot kernel protein and corn starch exhibit superior mechanical, barrier, and optical properties compared to individual protein or starch films. The addition of hydrophobic additives further increased the hydrophobicity of the films, making them more water-resistant. The enhanced crystallinity along with the higher melting temperature and enthalpy, supports the improved structural integrity and performance of the composite films

Future Scope

- Explore the addition of other natural polymers to expand film functionality.
- Scale up production for industrial applications in real-world packaging conditions.
- Study the films' biodegradability and environmental impact under different conditions.
- Investigate the use of composite films in active and smart packaging systems

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