Development of Fennel-Infused Bioactive Film for Traditional Food Packaging

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ABSTRACT

INTRODUCTION

Plastic pollution is one of the biggest environmental challenges today, and it has encouraged researchers to look for sustainable alternatives to petroleum-based plastics (Bócoli *et al*., 2025). Plant-based ingredients such as fibers, powders, and essential oils are being tested as natural additives to improve these limitations. One such plant is Fennel (*Foeniculum vulgare Mill.*) with its promising potential. It is commonly used as a spice and herbal medication, and it is recognized for its strong antimicrobial, antioxidant, and medicinal properties (Noreen *et al*., 2023). These properties make fennel not only beneficial for health but also useful in packaging materials where natural protection against spoilage is required.

OBJECTIVES

To develop a biodegradable and functional fennel-infused starch film to improve mechanical strength and protective properties for food packaging applications.

METHODOLOGY

Fennel husk, first sieved, then dried at 50 °C, then ground into a fine powder and then extracted through the Soxhlet apparatus with ethanol for 6 to 8 hour leaving behind fennel husk oil rich in bioactive compounds such as anethole and fenchone. To prepare the film, 3 g of starch was dissolved in 100 mL of distilled water and heated to 80 °C under constant stirring until gelatinized. One gram of glycerol and 0.003 gram of citric acid were added and stirred for 10 minutes. Next, 1 mL of fennel husk oil was added drop by drop into the starch & glycerol mixture while stirring vigorously. The solution was added onto glass plates and dried at 40-45°C for 12-16 hours, followed by conditioning at 25°C and 50% relative humidity (Chi *et al*., 2024).

RESULT

Fennel husk oil-based packaging films were successfully prepared using starch as the polymer and glycerol as the plasticizer, and citric acid for improving strength, resulting in an even surface and good flexibility. Because funnel husk oil contains compounds such as anethole and fenchone, these films were found to have stronger antioxidant and antimicrobial activity compared to other films (Anwar *et al*., 2009; Noreen *et al*., 2023). Films were compact, showed no brittleness or cracks, and could be easily handled. From the analyses, husk oil films provide better transparency and potentially higher bioactive protection, showing strong potential as biodegradable active packaging materials, with different benefits depending on the type of food being packaged.

PROPERTIES	RESULTS
Film Thickness	0.14 - 0.20 mm
Tensile Strength	2.09 -7.12 MPa
Elongation at Break	40.6 -70.4%
Antioxidant Activity	~38-56%
Antimicrobial Zone of Inhibition	5-22 mm
Transparency	73 - 81%

CONCLUSION

Fennel husk extract oil, and citric acid are utilized to obtain efficient biodegradable, bioactive starch films acceptable for food packaging. These are the films that are concerned with environmental sustainability as well as natural antimicrobial protection, and this represents a promising alternative to conventional plastic packaging.

Keywords: Fennel Husk Oil, Biodegradable Film, Antioxidant, Antimicrobial, Eco Friendly.

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