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## Antibacterial and Antioxidant Bioactivity of Electrospun PVA Mats Loaded with Hydroalcoholic Extract of Iranian Propolis

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### Introduction

Free radicals are natural byproducts of cellular metabolism and play a key role in oxidative stress, leading to tissue damage and the progression of neurodegenerative disorders. Tissue engineering aims to repair and regenerate damaged tissues by combining cells with bioactive scaffolds that can modulate the cellular environment. Poly(vinyl alcohol) (PVA) is a hydrophilic, biocompatible polymer often used in biomedical applications but has limited bioactivity on its own. Propolis, a resinous substance collected by honeybees from plant sources, contains phenolic and flavonoid compounds with well-documented antioxidant and antimicrobial properties. In this study, electrospun PVA scaffolds enriched with a hydroalcoholic Iranian propolis extract (EEP) were fabricated and evaluated for their antioxidant potential, physicochemical properties, and biological performance (Figure 1).



Figure #1

### Methods

Iranian propolis was extracted by maceration in 70% ethanol, followed by filtration and concentration via rotary evaporation to yield the ethanolic extract of propolis (EEP). The antioxidant capacity of the extract was first verified using the DPPH radical scavenging assay. A 10 wt% PVA solution was prepared at 80 °C, and after cooling, 3 wt% of EEP (relative to PVA) was added and homogenized. Electrospinning was performed under a voltage of 20 kV with a needle-to-collector distance of 12 cm to obtain nanofibrous mats. Morphological features and fiber diameter distributions were observed via SEM (Figure 2). Surface wettability was assessed through contact angle measurements, while the L929 fibroblast cell line was used to evaluate cytocompatibility. Antimicrobial activity was determined by the disk diffusion method against standard ATCC strains of Gram-positive and Gram-negative bacteria. FTIR was used to analyze the functional group interactions between PVA and EEP (Figure 3).

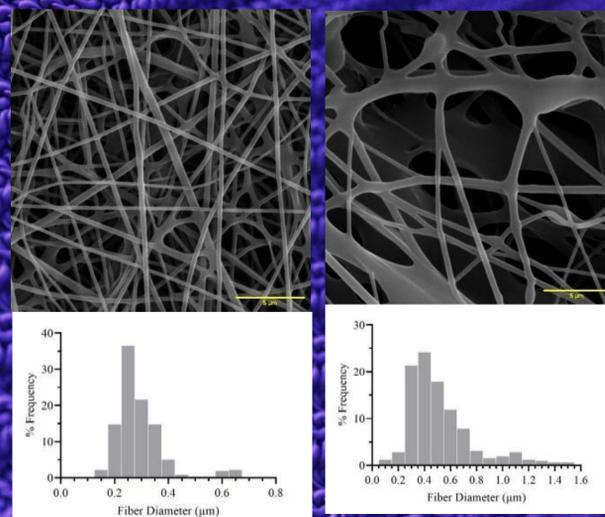


Figure #2

### Results

The DPPH assay confirmed the antioxidant potential of EEP, showing a dose-dependent radical scavenging effect, with concentrations up to 30 μL achieving significant inhibition (Figure 4). FTIR spectra of neat PVA exhibited characteristic peaks at 3200 cm<sup>-1</sup> corresponding to –OH stretching and at 1420 cm<sup>-1</sup> for CH/CH<sub>2</sub> vibrations. After EEP incorporation, new bands and slight shifts appeared in the 1400–1700 cm<sup>-1</sup> region, indicating hydrogen bonding interactions and the presence of phenolic and aromatic components from propolis (Figure 3). SEM analysis showed uniform, bead-free fibers with an average diameter of 0.2–0.4 μm for pure PVA mats, which increased to approximately 0.8 μm with EEP addition, suggesting partial viscosity enhancement due to propolis incorporation. The EEP-enriched mats exhibited improved structural stability and reduced contact angles (47°), indicating enhanced hydrophilicity. Cell culture assays with L929 fibroblasts demonstrated superior adhesion and proliferation on EEP-loaded scaffolds compared to control mats. Moreover, the disk diffusion tests showed clear inhibition zones against both Gram-positive and Gram-negative bacterial strains, confirming the antibacterial efficacy of propolis-enriched mats (Figure 5).

Figure #3

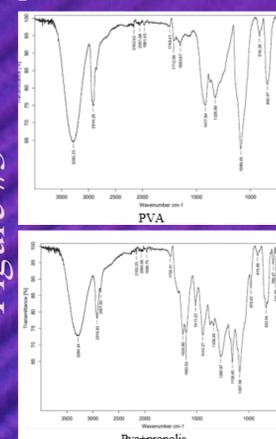
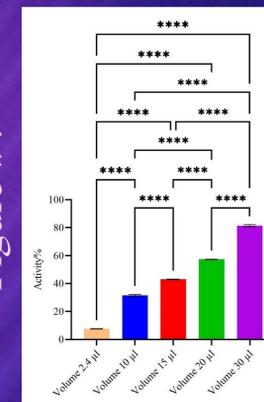


Figure #4



### Conclusions

This work demonstrates that integrating propolis extract into electrospun PVA scaffolds significantly enhances their antioxidant, antibacterial, and cytocompatible properties. The phenolic compounds in propolis not only impart free radical scavenging activity but also improve surface wettability and support fibroblast proliferation. The dual antioxidant and antimicrobial functionality of EEP-loaded scaffolds positions them as promising candidates for wound healing and tissue regeneration. Moreover, the demonstrated antioxidant potential suggests potential applications in mitigating oxidative stress associated with neurodegenerative disorders. The novelty of this study lies in developing a simple, eco-friendly electrospinning strategy that yields bioactive PVA/propolis nanofibrous mats with multifunctional therapeutic potential.

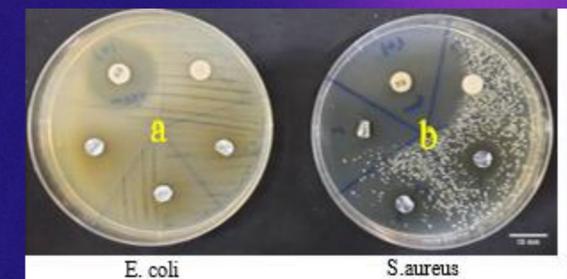


Figure #5

### Bibliography

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- 2.Z. Zelca, R. Merijs-Meri, A. Krumme, and A. Bernava, "Electrospun Fibrous Materials with Propolis Extracts for Edible Food Packagings." *Molecules*, Vol. 28 (No. 14), Jul 19 (2023).