Development of a Novel Gelatin and Hyaluronic Acid Sponge Incorporated With Lavender for Palatal Wound Healing

VT Indu Gayathrie1 , G.Shreya1,a)

1Indu Dental Centre, New Delhi, India

Corresponding Author: a)[shreyayerramalli3@gmail.com](mailto:shreyayerramalli3@gmail.com)

**Abstract:** Palatal wounds, commonly resulting from dental procedures involving connective tissue grafts, require effective healing solutions due to their susceptibility to infection, discomfort, and delayed recovery. Current wound care methods may not adequately address the unique challenges of the oral environment, prompting interest in natural, biocompatible dressings. This study aims to develop a novel wound-healing sponge incorporating gelatin, hyaluronic acid (HA), and lavender essential oil, leveraging their combined structural, hydrating, and antimicrobial properties. The sponge was prepared by mixing gelatin and HA in a lavender extract solution, followed by deep-freezing at -80°C and lyophilization to achieve a porous structure. Fourier Transform Infrared Spectroscopy (FT-IR) confirmed the integration of all components, while mechanical testing demonstrated enhanced tensile strength, ensuring durability for clinical use. Contact angle analysis revealed optimal wettability, promoting a moist wound environment conducive to healing, and blood compatibility tests indicated minimal cytotoxicity, supporting safe application in the oral cavity. These findings suggest that the gelatin-HA-lavender sponge is a promising biocompatible wound dressing that combines structural support, hydration, and antimicrobial protection. Future studies, including clinical trials, are recommended to further assess its efficacy, degradability, and patient acceptance, with the goal of advancing wound care in both dental and broader medical applications.

**Keywords:** lavender, gelatine sponge, hyaluronic acid.

# INTRODUCTION

Palatal wounds are a prevalent complication in dental procedures, particularly in surgeries involving connective tissue grafts aimed at treating gingival recession. The palatal donor site, often left exposed, can be a source of significant discomfort and prolonged healing for patients. Effective wound healing in these cases is essential, not only for reducing recovery time but also for minimizing the risk of infection and improving patient outcomes.[(Qiu et al., 2025)](https://paperpile.com/c/uSqlGp/rf6da) Traditional methods of wound care, such as gauze dressings or synthetic wound healing agents, may not always provide optimal results in terms of comfort or efficacy, especially in an oral environment continuously exposed to saliva and microorganisms. Consequently, there is a growing interest in natural, biocompatible, and effective wound healing solutions specifically designed for oral applications .[(Zhang et al., 2024)](https://paperpile.com/c/uSqlGp/bt8Oq)Gelatin is a naturally derived polymer commonly used in tissue engineering due to its high biocompatibility, biodegradability, and ability to promote cell adhesion and proliferation. In wound healing applications, gelatin has shown promising results in creating moist healing environments, which are critical for efficient tissue regeneration[(Khajavi et al., 2025)](https://paperpile.com/c/uSqlGp/QgLPA). Gelatin also contains numerous amino acid residues that can interact with cellular receptors, potentially enhancing cellular responses involved in wound healing. Studies have shown that gelatin-based sponges provide a porous structure beneficial for cell migration and vascularization, both of which are key factors in wound healing (Wang et al., 2006).[(H. Wang et al., 2025)](https://paperpile.com/c/uSqlGp/rTkz2)Hyaluronic acid (HA), another key component in the sponge formulation, is a polysaccharide present in the extracellular matrix of various tissues. It plays a critical role in wound healing by promoting cell migration, hydration, and angiogenesis. [(Gandhi et al., 2021; Janani et al., 2021; Ganapathy, 2021)](https://paperpile.com/c/uSqlGp/wUF3w+oizLT+FvV7i) Its hydrophilic properties contribute to maintaining a moist wound environment, which is known to accelerate the healing process[(Hanari et al., 2025)](https://paperpile.com/c/uSqlGp/Weaxc). HA has also been shown to exhibit anti-inflammatory properties by modulating the local immune response, reducing the risk of infection, and assisting in the regeneration of damaged tissues. Additionally, HA has been used effectively in oral wound healing, with research demonstrating its ability to promote faster wound closure, increase fibroblast activity, and facilitate epithelial repair .[(Razali et al., 2024)](https://paperpile.com/c/uSqlGp/bxz6I)Lavender essential oil, incorporated into the sponge, has been recognized for its antimicrobial, anti-inflammatory, and analgesic properties. These attributes make it particularly valuable in wound healing, as lavender oil can help prevent infection while reducing inflammation and pain at the wound site.[(Tan et al., 2025)](https://paperpile.com/c/uSqlGp/NSeTV) Its application in wound healing is supported by research indicating that lavender oil can accelerate wound closure and reduce bacterial load, which is crucial in oral environments where bacterial exposure is high . Research suggests that the inclusion of lavender essential oil in wound dressings provides additional benefits by promoting cell proliferation and reducing inflammatory markers at the wound site, which can be especially beneficial for oral wounds.[(Feng et al., 2024)](https://paperpile.com/c/uSqlGp/ZSnps)The combination of gelatin, hyaluronic acid, and lavender oil in a sponge provides a synergistic effect. Gelatin offers a structural matrix that supports cell proliferation and tissue regeneration, while HA maintains a moist wound environment and promotes cellular migration. Lavender oil adds antimicrobial and anti-inflammatory effects, making this combination ideal for addressing the specific challenges of palatal wound healing.[(Dharman et al., 2023; Govindaraj et al., 2023; Neeharika et al., 2023; Ramalingam et al., 2023)](https://paperpile.com/c/uSqlGp/OHjqq+H23QF+03FrU+OKDNq) The sponge’s ability to adhere to moist surfaces and release its active components gradually could further enhance its effectiveness in the oral cavity.[(Y. Wang et al., 2025)](https://paperpile.com/c/uSqlGp/vCK7y)

In this study, a novel gelatin and HA-based sponge incorporated with lavender essential oil is developed with the goal of improving healing outcomes for palatal wounds. The preparation process involves lyophilization, which creates a porous structure ideal for absorbing exudates and maintaining the moist environment conducive to wound healing.

# MATERIALS AND METHOS

## Lavender Extract Preparation

To incorporate lavender’s therapeutic properties, lavender extract was prepared by mixing 5 grams of lavender powder with 100 mL of water, following a process to optimize the extraction of bioactive compounds. The resulting extract was used in the preparation of the sponge, imparting its antimicrobial and analgesic benefits (Biazar & Keshel, 2015).

## Sponge Composition

The primary components, gelatin (1 gram) and hyaluronic acid (1 gram), were mixed into the lavender extract solution (100 mL). This combination was deep-frozen at -80°C for 24 hours before lyophilization to create a porous structure. Such a structure is advantageous for wound healing as it facilitates air permeability and fluid absorption (Mohamad et al., 2018).

## Characterization and Testing

To confirm the structural composition of the sponge, Fourier Transform Infrared Spectroscopy (FT-IR) was employed. This technique verifies the presence of key functional groups associated with gelatin, HA, and lavender components, thus ensuring successful integration of these elements (Zhao et al., 2021).

Mechanical properties such as tensile strength were assessed using a universal testing machine. This evaluation is crucial, as the sponge needs to withstand mechanical stresses while maintaining its integrity on the wound site (Xu et al., 2016).

## Blood Compatibility and Contact Angle Analysis

To ensure the safety and effectiveness of the sponge in a clinical setting, blood compatibility tests were conducted. Minimal blood cell lysis indicated that the sponge is non-cytotoxic, aligning with the requirements for biocompatibility. Contact angle analysis further revealed that the sponge’s hydrophilic nature is conducive to wound healing by maintaining a moist environment (Khan et al., 2017).

The results of these tests confirm the effectiveness and potential of the gelatin-hyaluronic acid-lavender sponge for wound healing:

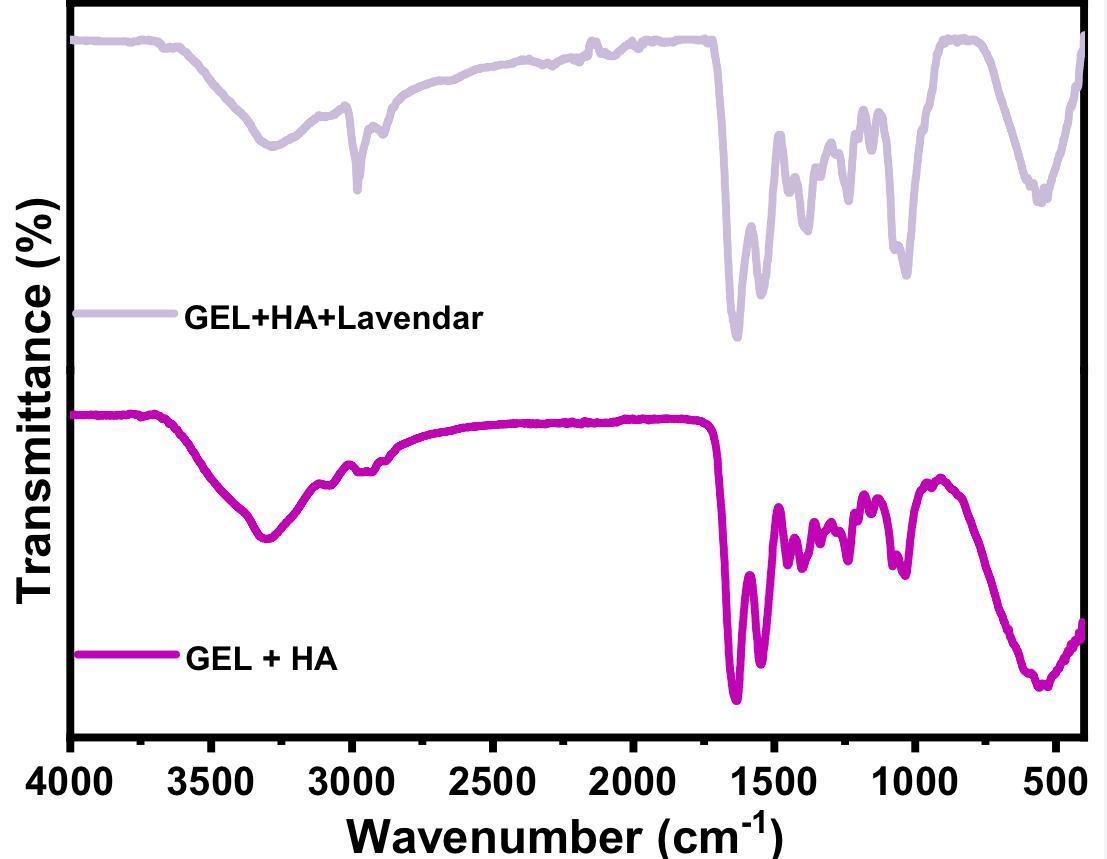


FIGURE 1: Transmittance vs Wavenumber

## FT-IR Analysis

Graph Description: FT-IR spectra showing characteristic peaks corresponding to gelatin, hyaluronic acid, and lavender.

Interpretation: The presence of all components confirmed through distinct absorption bands. The presence of carboxylate group in the lavender infused gelatine HA sponge confirms incorporation of lavender into the Gelatine HA sponge.

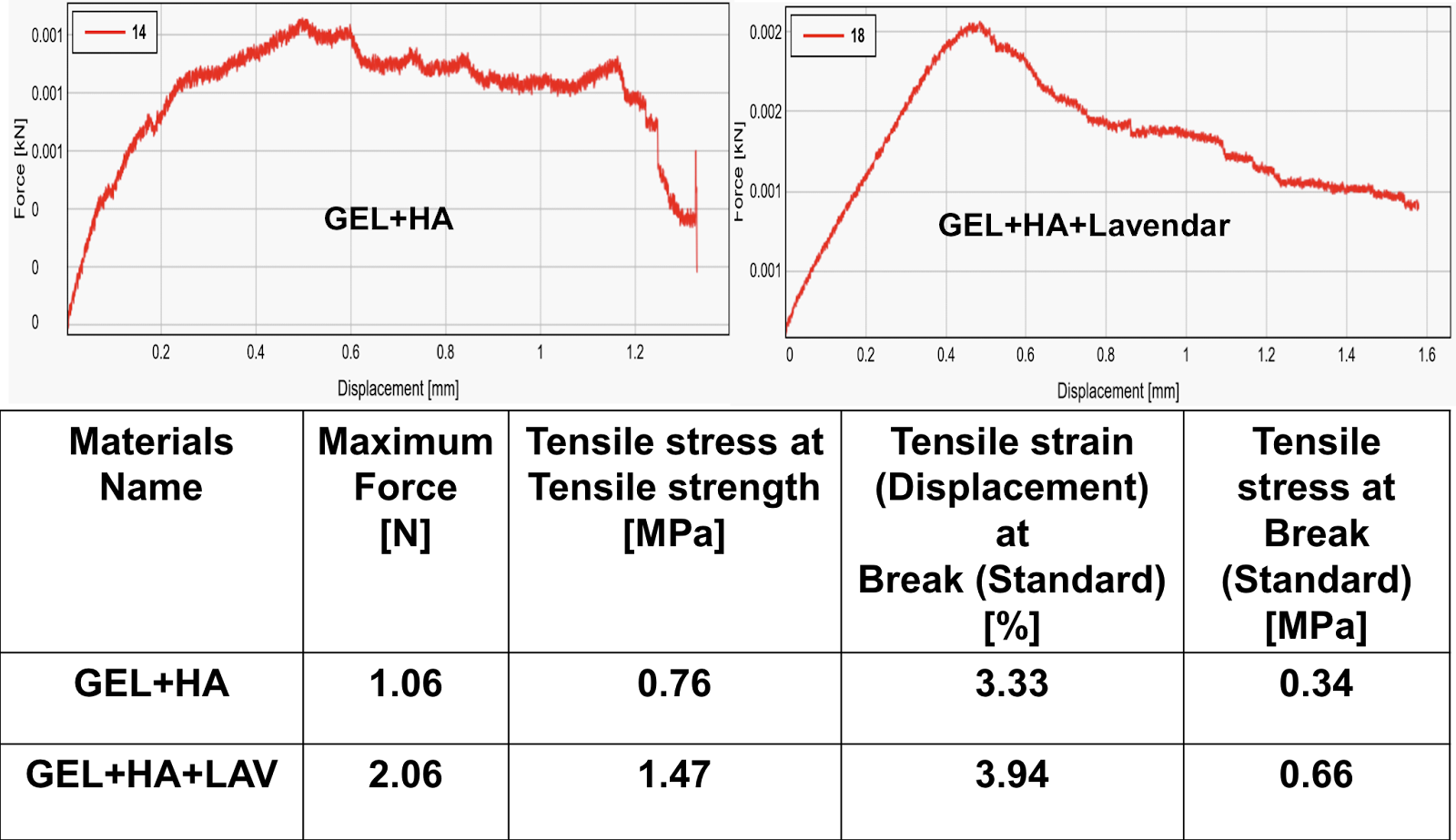
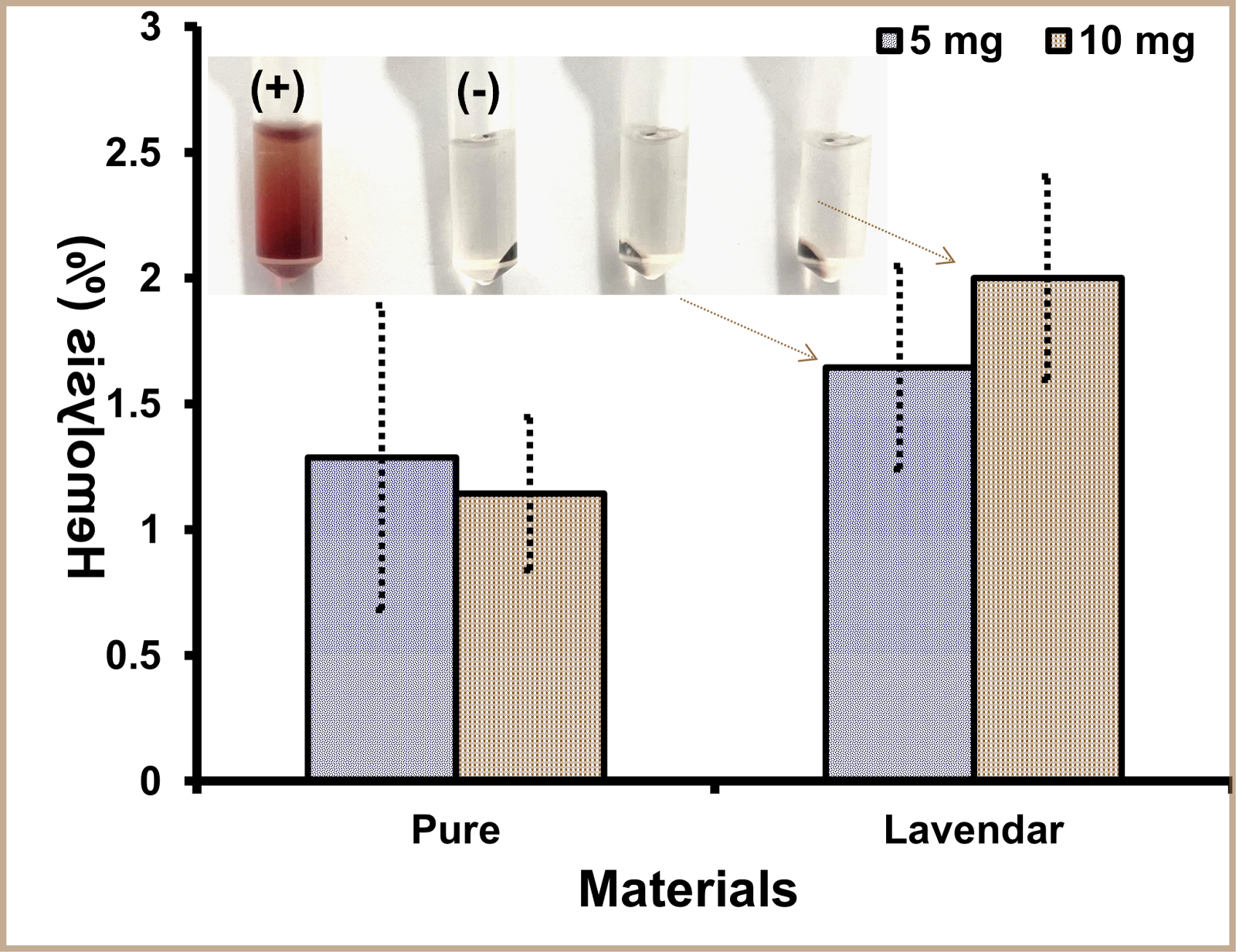


Figure 2: FT-IR analysis

## Tensile Strength

Tensile strength values indicating the mechanical robustness of the sponge.

- Interpretation: The test sponge exhibits comparatively more mechanical strength than that of the control group.



**FIGURE 3: Hemolysis vs materials**

## Blood Compatibility

Hemocompatibility results showing minimal blood cell lysis or clotting. Even though lavender had more hemolysis it’s within appropriate amounts.

- Interpretation: The sponge is safe for direct contact with blood, crucial for wound healing applications.

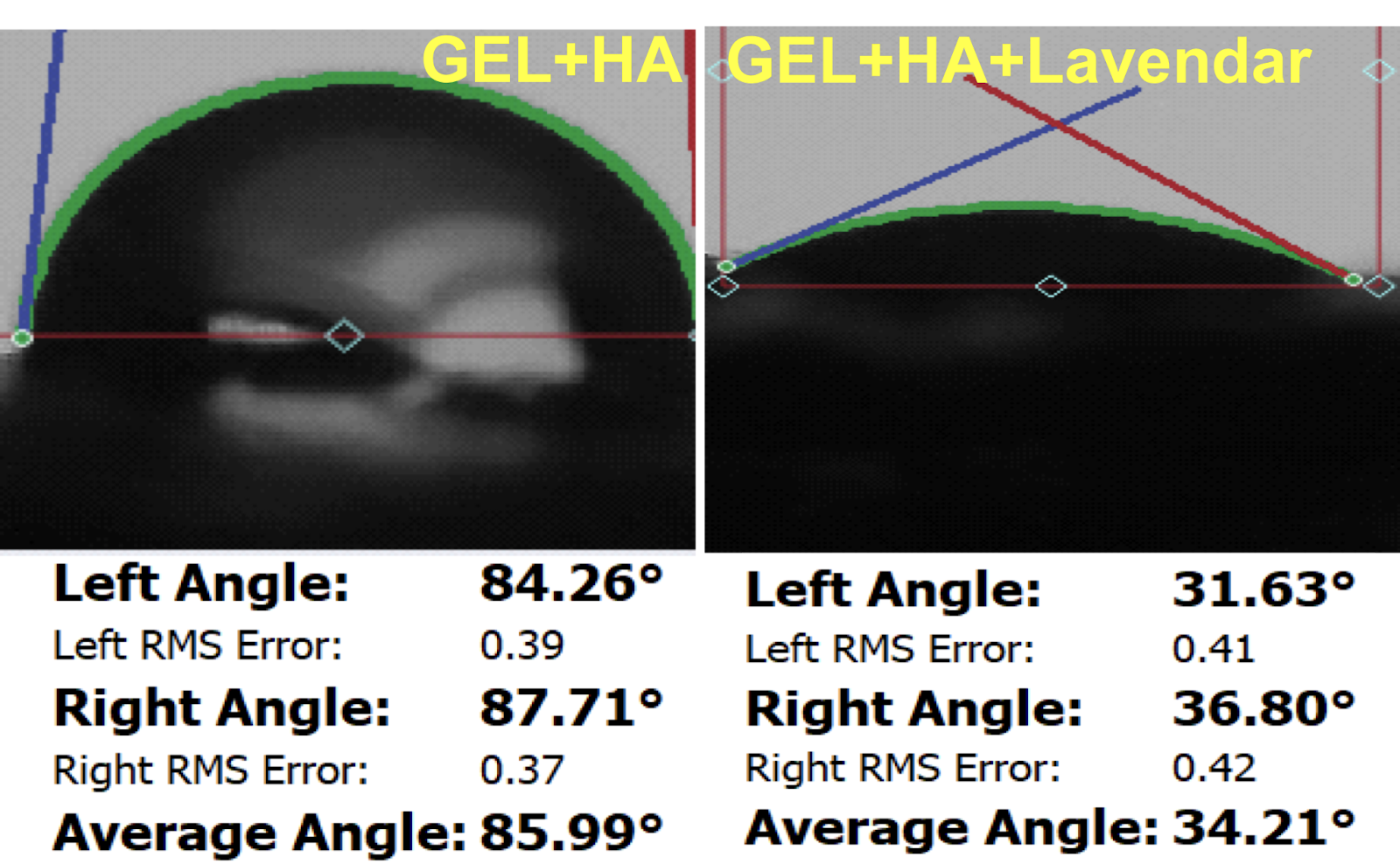


FIGURE 4: Blood compatability

## Contact Angle

Contact angle measurements showing the degree of wettability.Interpretation: The sponge has a suitable contact angle, indicating its compatibility with moist wound environments.

# Discussion

The novel sponge developed in this study addresses several key aspects of wound healing, particularly for applications in the oral cavity where the healing environment presents unique challenges. [(Kachhara et al., 2021; Lakshmi, 2021; Lampl et al., 2023; Subramanian et al., 2023)](https://paperpile.com/c/uSqlGp/jlY1S+4weDq+ASYv3+en7kU) The combination of gelatin, hyaluronic acid, and lavender essential oil offers multiple benefits, including biocompatibility, moisture retention, structural integrity, and antimicrobial properties. Each component plays a critical role in enhancing the wound healing process.[(Ana et al., 2025)](https://paperpile.com/c/uSqlGp/qqI5q)Gelatin provides the structural framework necessary for cell adhesion and tissue regeneration. Its biocompatibility ensures that it does not elicit adverse immune responses, making it suitable for applications in sensitive areas like the oral cavity(Rafi et al., 2024). Moreover, the porous nature of gelatin sponges, achieved through the lyophilization process, allows for adequate oxygen exchange and fluid absorption, which are essential for wound healing[(Hussein et al., 2024)](https://paperpile.com/c/uSqlGp/cM4Qd)Hyaluronic acid, with its hydrophilic properties, is indispensable for maintaining the moist environment that accelerates wound healing (Tuluwengjiang et al., 2024). Studies show that HA not only enhances hydration but also supports cellular processes such as migration and proliferation, which are crucial during the repair phase. In wound models, HA has been shown to promote angiogenesis, a key factor in forming new tissue and improving wound closure rates[(Ehab et al., 2020; Hussein et al., 2024)](https://paperpile.com/c/uSqlGp/cM4Qd+K7l6N)Lavender essential oil’s role as an antimicrobial and anti-inflammatory agent further enhances the sponge’s effectiveness.[(Doshi et al., 2023; Pandiyan et al., 2023; Pavithra et al., 2023; A. A. Thomas & Jain, 2023)](https://paperpile.com/c/uSqlGp/ofW2u+ifeqf+zt0XK+xft3R) Research has demonstrated that lavender oil can reduce bacterial load and inflammation at the wound site, aiding in pain management and reducing the risk of infection. Its inclusion in the sponge could therefore play a pivotal role in reducing complications associated with wound healing in the oral cavity.[(Belkhede et al., 2019)](https://paperpile.com/c/uSqlGp/SZeVi)The results of this study indicate that the gelatin-HA-lavender sponge has adequate mechanical strength to withstand oral cavity forces, which is essential for clinical applicability.[(Ramsundar et al., 2023; Rieshy V. et al., 2023; Shenoy et al., 2023; Singh et al., 2023)](https://paperpile.com/c/uSqlGp/noRrh+MApTj+PXDBO+zZhOy) Additionally, the biocompatibility tests show minimal blood cell lysis, suggesting the sponge is safe for direct contact with oral tissues.[(S. Thomas, 1990)](https://paperpile.com/c/uSqlGp/xu7jG) These properties collectively suggest that the sponge could provide a natural, effective, and convenient option for patients requiring wound care post-dental surgery, potentially reducing healing time and improving patient comfort.[(Belkhede et al., 2019; Sousa et al., 2020)](https://paperpile.com/c/uSqlGp/SZeVi+6JZjF)While the preliminary results are promising, further studies, including comprehensive clinical trials, are needed to verify the sponge’s efficacy and safety in clinical dental settings. Future research should explore drug release profiles, degradability, and patient-reported outcomes to fully establish the potential of this novel wound-healing sponge.

# Conclusion

The novel gelatin and hyaluronic acid sponge infused with lavender essential oil offers an effective and natural treatment for palatal wounds. Its combination of enhanced tensile strength, biocompatibility, and moisture retention presents a compelling case for its use in dental wound management, marking a meaningful advancement in wound care technology.

This sponge could significantly improve patient comfort and clinical outcomes, providing a biocompatible, user-friendly solution for wound healing. Its success in palatal applications could potentially be extended to other medical fields where natural, biocompatible dressings are preferred.While the preliminary results are promising, further studies, including comprehensive clinical trials, are needed to verify the sponge’s efficacy and safety in clinical dental settings. Future research should explore drug release profiles, degradability, and patient-reported outcomes to fully establish the potential of this novel wound-healing sponge.In conclusion, the gelatin and HA sponge with lavender presents a promising advancement in dental wound healing, offering a natural alternative to synthetic dressings. Future studies, including clinical trials, will be necessary to fully validate the sponge’s efficacy and determine its long-term safety and effectiveness in routine dental practice.

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