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Development of Photo-crosslinked Hydrogel incorporated with Curcumin/ Rutin for Wound Healing: An Invitro Study

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Abstract

Introduction:

Wound healing is a complex biological process composed of interrelated and overlapping phases: inflammation, migration, proliferation, and maturation. In severe wounds, such as large skin injuries, second or third-degree burns, or diabetes foot ulcers, wound healing is a slow process and rarely leads to the complete restoration of tissue function. Hydrogels are three-dimensional polymeric networks that can swell in aqueous environment/biological fluids by absorbing the wound exudates while preventing wound dehydration.

Aim:

The aim of the study is to explore the development of a photo-crosslinked hydrogel incorporated with two potent natural compounds, curcumin and rutin and its efficacy in promoting wound healing.

Materials and methods:

Formation of hydrogel incorporated in correct proportions of curcumin and rutin was done. 10% gelatin was added and mixed with ethylene glycol to form gelatin methacrylate. 0.5 % of carrageenan was used. Rutin and curcumin in optimized concentration and 1:1 ratio stock sol. was used. It was then placed in 6 wells for room temp (30 minutes - 1 hour). Potassium chloride (KCl) was added for chemical cross linking, and it was then frozen at 80 degrees C and was lyophilized.

Results:

The results showed high ability of antimicrobial activity, Antioxidant activity, Compatibility and Anti-inflammatory properties for the photo-crosslinked hydrogel incorporated with curcumin and rutin.

Conclusion:

It can be concluded from our study that the development of a photo-crosslinked hydrogel incorporated with curcumin and rutin represents a promising approach for enhancing wound healing.

Keywords: Antimicrobial, anti-inflammatory, curcumin, nanoparticles, rutin, novel product, innovative technique, hydrogel, wound healing, anti-oxidant

INTRODUCTION

Wound healing is a complex process involving various cellular and molecular events. Over the years, researchers have explored innovative materials to enhance the wound healing process. Photo-crosslinked hydrogels, a class of three-dimensional polymer networks, have gained significant attention due to their versatility and ability to mimic the extracellular matrix [1].

Curcumin is known for its anti-inflammatory and antibacterial effects, while rutin exhibits antioxidant and angiogenic properties. By incorporating these bioactive compounds into the hydrogel, a synergistic effect is anticipated, promoting enhanced wound healing. The hydrogel provides a sustained release of curcumin and rutin at the wound site, creating an

optimal microenvironment for tissue regeneration [2].

In the pursuit of innovative solutions for wound healing, researchers have turned their attention to advanced biomaterials, among which photo-crosslinked hydrogels stand out. These three-dimensional polymeric networks possess unique properties that make them ideal candidates for mimicking the extracellular matrix, providing a supportive environment for tissue repair [3]. This article delves into the fascinating realm of developing a photo-crosslinked hydrogel enriched with the potent natural compounds such as curcumin and rutin, and exploring the synergistic effects of these bioactive agents in promoting wound healing [4].

Hydrogels have emerged as promising platforms for drug delivery and tissue engineering due to their high-water content, biocompatibility, and tunable physical properties. The incorporation of therapeutic agents into hydrogel matrices enhances their functionality, making them valuable tools for targeted wound care [5]. Curcumin, derived from turmeric, and rutin, a flavonoid found in various plants, boast well-documented anti-inflammatory, antioxidant, and regenerative properties, making them compelling candidates for inclusion in wound healing formulations [6].

As we embark on this exploration, we will delve into the intricate process of developing a photo-crosslinked hydrogel and the scientific rationale behind incorporating curcumin and rutin. Furthermore, we will examine the promising results observed in preliminary studies, shedding light on the potential of this innovative biomaterial to revolutionize approaches to wound healing [7]. The intricate interplay between hydrogel engineering and the bioactive potential of curcumin and rutin opens new avenues for research and may pave the way for transformative advancements in the field of regenerative medicine [8].

The aim of the study is to explore the development of a photo-crosslinked hydrogel incorporated with two potent natural compounds, curcumin and rutin and its efficacy in promoting wound healing.

MATERIALS AND METHODS

Hydrogel Development:

The hydrogel is developed through a photo-crosslinking process, creating a stable and biocompatible scaffold. This process allows for the incorporation of therapeutic agents, such as curcumin and rutin, into the hydrogel matrix. Curcumin, derived from turmeric, and rutin, a flavonoid found in certain fruits and vegetables, are chosen for their well-documented anti-inflammatory and antioxidant properties.

Development of mixture:

Formation of hydrogel incorporated in correct proportions of curcumin and rutin was done (Figure 1). 10% gelatin was added and mixed with ethylene glycol to form gelatin methacrylate. 0.5 % of carrageenan was used. Rutin and curcumin in optimized concentration and 1:1 ratio stock sol. was used. It was then placed in 6 wells for room temp (30 minutes - 1 hour). Potassium chloride (KCl) was added for chemical cross linking, and it was then frozen at 80 degrees C and was lyophilized.

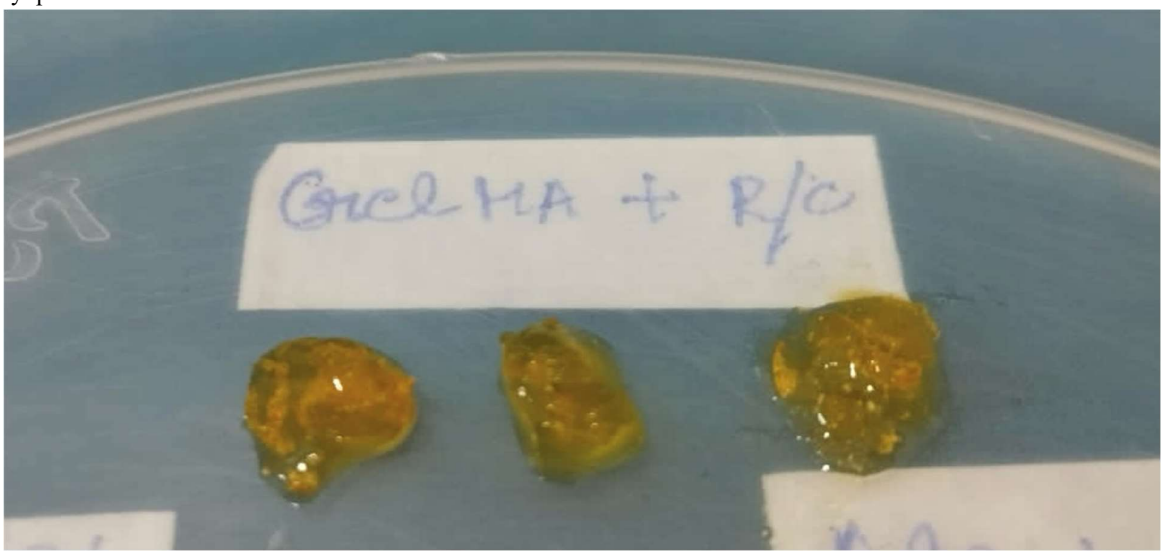

Figure 1. Depicts the incorporated hydrogel with Curcumin and rutin

RESULTS

The results showed high ability of antimicrobial activity (Figure 2), Antioxidant activity (Figure 3), Compatibility (Figure 4) and Anti-inflammatory properties (Figure 5) for the photo-crosslinked hydrogel incorporated with curcumin and rutin. Scanning electron microscope (SEM) image showed the incorporated hydrogel with curcumin and rutin (Figure 6).

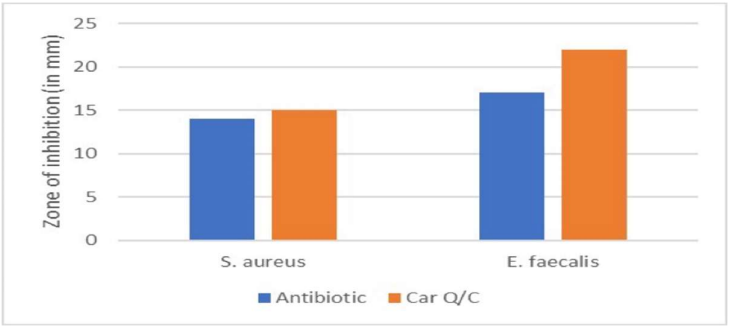

Figure 2: Bar graph representing Antimicrobial activity

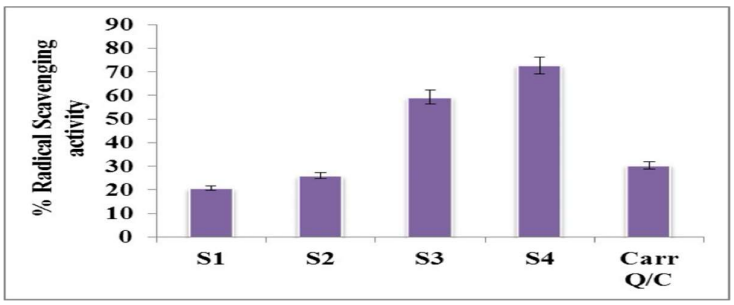

Figure 3: Bar graph representing Antioxidant activity

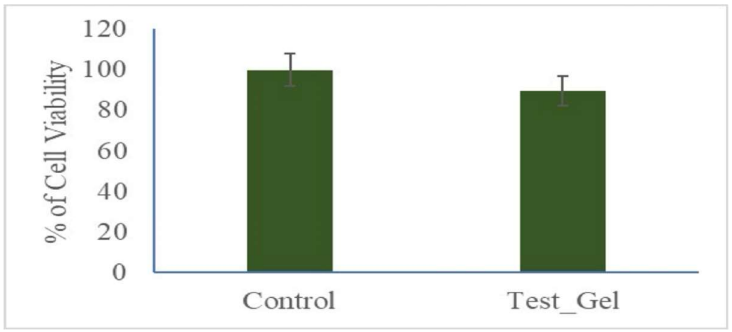

Figure 4: Bar graph representing Compatibility test

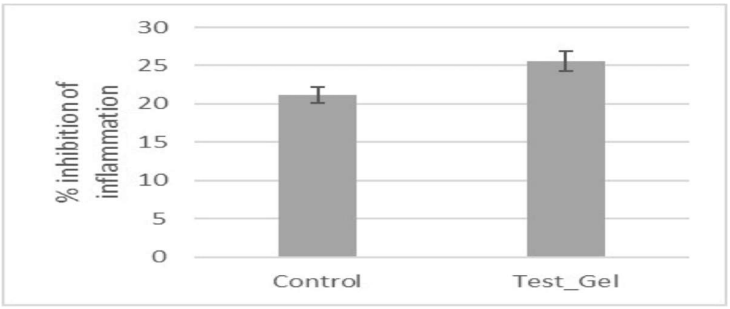

Figure 5: Bar graph representing Anti-inflammatory activity

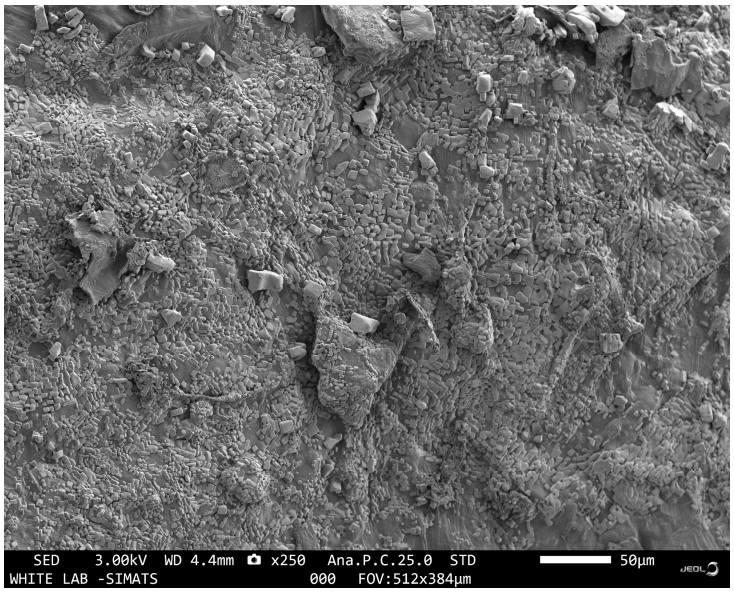

Figure 6: Scanning electron microscope (SEM) image showing the result for incorporated Hydrogel

DISCUSSION

Preliminary studies suggest that the photo-crosslinked hydrogel incorporated with curcumin and rutin accelerates wound closure and promotes tissue regeneration compared to control groups. The anti-inflammatory and antioxidant properties of curcumin and rutin contribute to a favorable wound healing microenvironment [9-11].

The amalgamation of photo-crosslinked hydrogel technology with the therapeutic potential of curcumin and rutin marks a significant stride in the pursuit of advanced wound healing solutions [10]. The multifaceted nature of this research warrants a thorough discussion, encompassing the intricacies of hydrogel development, the synergistic effects of incorporated bioactive compounds, and the implications of observed outcomes in wound healing studies [11].

The photo-crosslinking process employed in hydrogel development is pivotal for creating a scaffold that closely mimics the natural extracellular matrix. This technique imparts desirable properties such as enhanced stability and tunable mechanical characteristics to the hydrogel [12]. These features are crucial for creating a supportive environment for cellular activities involved in wound healing, including adhesion, migration, and proliferation. The resulting three-dimensional structure of the hydrogel provides a promising foundation for targeted drug delivery and tissue regeneration [13].

The decision to incorporate curcumin and rutin into the hydrogel matrix stems from the well-established therapeutic properties of these natural compounds [14]. Curcumin, with its anti-inflammatory and antibacterial attributes, complements rutin's antioxidant and angiogenic effects. This combination is designed to address various aspects of the wound healing cascade, from mitigating inflammation to promoting tissue regeneration [15,16]. The controlled release of these bioactive compounds from the hydrogel further ensures a sustained therapeutic effect at the wound site [17].

Biocompatibility and cytotoxicity studies are critical milestones in assessing the safety profile of the developed hydrogel. These in vitro evaluations provide essential insights into the potential impact on cell viability and guide decisions regarding the translational potential of the hydrogel for clinical use [18]. The positive outcomes from these studies lay the foundation for progressing to in vivo wound healing investigations [19-21].

In vivo studies utilizing animal models play a central role in validating the efficacy of the hydrogel in a physiological context. The observed acceleration in wound closure and enhanced tissue regeneration in the presence of the photo-crosslinked hydrogel enriched with curcumin and rutin suggests a synergistic effect [22-24]. The anti-inflammatory, antibacterial, and angiogenic properties of the incorporated compounds contribute to creating an optimal microenvironment for wound healing [25-27].

The results obtained from these studies open avenues for further optimization of the hydrogel formulation and exploration of potential variations in concentrations of curcumin and rutin. Additionally, long-term studies would be valuable to assess the sustained effectiveness of the hydrogel and potential implications for scar formation.

In the current study, a novel wound dressing made of photo-crosslinked hydrogels and incorporated curcumin/ rutin into the hydrogel as a drug delivery vehicle was fabricated. It has been reported that topically administered curcumin is a promising wound healing agent with anti-inflammatory, antimicrobial, anti-oxidant, and antineoplastic effects. One approach to improve the delivery efficiency of curcumin through the skin layers is to encapsulate it inside nanoparticles.

Thereafter, this platform as a wound dressing can be used in skin injuries.

CONCLUSION

It can be concluded from our study that the development of a photo-crosslinked hydrogel incorporated with curcumin and rutin represents a promising approach for enhancing wound healing. While further research is needed to validate these findings and optimize the formulation, the initial results highlight the potential of this innovative biomaterial in advancing wound care therapies. This research may pave the way for the development of new, effective strategies in the field of regenerative medicine and wound healing.

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Nil

Conflicts of Interest

None declared.

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