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Research article

From plant to patch: Okra-enriched wound dressings for superior tissue regeneration

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Abstract

Natural polymers have gained increasing attention in wound-care research due to their biocompatibility and their capacity to support key cellular activities involved in tissue repair. Plant-derived polysaccharides have been investigated for their ability to contribute to moisture balance, cell adhesion, and matrix formation, processes essential for the early stages of healing. Okra mucilage (OM), a polysaccharide-rich extract obtained from *Abelmoschus esculentus*, contains structural and nutritional components that are known to influence cellular behavior and may therefore improve the initial cell–material interactions required for effective wound-dressing performance. In this study, OM was integrated into a commercially available hydrofiber wound dressing using a simple immersion method. The modified dressings were characterized by FTIR to confirm OM incorporation and were evaluated *in vitro* using Human Keratinocyte Cell Lines (HaCaT) through MTT-based viability assays and SEM analysis of cellular adhesion. OM-enriched dressings exhibited increased early-phase cell viability, most prominently at 24 hours, and demonstrated enhanced cell attachment compared with untreated dressings and controls. These findings suggest that OM can positively modulate early cellular responses relevant to wound repair when applied to an established hydrofiber platform.

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Keywords: *Abelmoschus esculentus; bioactive wound dressing; Okra mucilage; skin regeneration; wound healing*

1. Introduction

The skin, our body's largest organ, is vital for essential physiological functions such as gas exchange, thermoregulation, and environmental interaction via a sophisticated receptor network. Given its constant exposure, the integument is inherently susceptible to injury and trauma. Consequently, the timely and effective management of any cutaneous damage is paramount. The global impact of skin wounds continues to represent a substantial healthcare and socioeconomic burden. Each year, countless wounds, including injuries, burns, ulcers, and surgical incisions, demand considerable financial and medical resources for their treatment (Eslahi et al., 2024; Zhang et al., 2024; Cong et al., 2025; Matini et al., 2025; Millotti, et al., 2025).

A wound represents a loss of tissue continuity arising from mechanical, chemical, or metabolic insults, and its repair triggers a tightly coordinated physiological response. This endogenous healing sequence unfolds through four mutually dependent phases, haemostasis, inflammation, proliferation, and extracellular matrix (ECM) remodeling, each regulated by intricate molecular and cellular signaling networks (Fernandes et al., 2023; Ahmed et al., 2024). Wound healing is an organized process that follows the disruption of tissue integrity. Initially, haemostasis is achieved through vascular spasm, followed by platelet aggregation and the formation of a primary clot. The inflammatory phase then begins, with neutrophils and macrophages removing necrotic tissue and microbial

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contaminants. In the subsequent proliferation phase, fibroblasts produce collagen and extracellular matrix, forming granulation tissue. Simultaneously, keratinocytes migrate through the epithelial tissue, forming new capillaries. Finally, in the maturation phase (remodeling), the collagen produced is replaced by mature collagen, increasing wound strength (Guo et al., 2010; Schreml et al., 2010; Wallace et al., 2017).

Unlike acute, uncomplicated wounds, chronic wound healing is characterized by delayed and dysregulated progression. Diabetic wounds, for instance, frequently become arrested in the inflammatory phase, failing to complete the four classical stages of healing (haemostasis, inflammation, proliferation, and maturation). Inflammation phase plays a pivotal role by orchestrating the infiltration of immune cells such as neutrophils and macrophages, which are essential for debris clearance, infection control, and initiation of regenerative pathways (Matini et al., 2025). When this stage is impaired or excessively prolonged, chronic inflammation, sustained microbial burden, and tissue damage can develop, ultimately giving rise to wounds that fail to heal. This clinical challenge underscores the necessity for targeted therapeutic interventions capable of modulating the natural repair process (Demiröz et al., 2019; Falanga et al., 2022; Wang et al., 2022; Worsley et al., 2023; Dawi et al., 2025).

Wound dressings are essential tools used to support the complex healing process. Current research consistently demonstrates that maintaining a moist wound environment significantly accelerates recovery. In such an environment, growth factors and cytokines function optimally, epithelial cell migration is facilitated, and autolytic debridement (removal of dead tissue by the body's own enzymes) is promoted. Beyond fostering an ideal biological milieu, dressings also serve to keep the wound clean pre-surgically, prevent microbial ingress, and offer protection from physical trauma. In essence, wound dressings are indispensable for maintaining optimal moisture balance, preventing infection, and providing mechanical safeguarding (Alberts et al., 2025; Ferraz, 2025; Shariatzadeh et al., 2025).

Historically, the most impactful wound treatments have involved multifunctional dressings, incorporating either synthetic or naturally derived bioactive compounds. These advanced dressings offer a wide spectrum of therapeutic benefits. While traditional gauze dressings are economical, they often fail to adequately absorb copious exudate and can dry out, leading to hardened edges around the wound. In contrast, modern dressings represent advanced materials engineered to consistently maintain a moist wound environment, manage exudate effectively, and deliver targeted therapies when required. Though their specific characteristics vary by material type, these contemporary dressings are generally non-adherent, sterile, capable of controlled permeability, provide thermal insulation, and exhibit flexibility. Beyond mere coverage of dermal lesions, modern wound care products are designed to minimize potential medical complications and actively promote the distinct phases of wound repair (Dong et al., 2024; Akhavan-Kharazian et al., 2025; Millotti et al., 2025, Moradifar et al., 2025)

Hydrofiber dressings represent a contemporary class of highly absorbent wound management materials, fabricated from cellulose-derived fibers, specifically sodium carboxymethyl cellulose (CMC). Upon contact with aqueous wound exudate, these dressings undergo a physical transformation, converting into a cohesive gel. This gel formation effectively sequesters wound fluid, thereby establishing a moist, non-adherent, and protective microenvironment directly on the wound bed. The resultant gel phase plays a crucial role in facilitating wound healing by retaining essential moisture, which in turn promotes epithelial cell migration and the development of granulation tissue. Furthermore, the gel-forming fibers act as a barrier against bacterial infiltration and enable atraumatic dressing removal, preventing adherence to delicate epithelial tissue. Hydrofiber dressings constitute a highly efficacious choice for managing wounds characterized by moderate to heavy exudation. Their utility is particularly pronounced in chronic wounds with substantial fluid secretion, such as diabetic foot ulcers, advanced-stage pressure injuries (specifically stages 3 and 4), and venous ulcers. These dressings also offer versatility in addressing tunneled or deep cavity wounds, as their conforming nature allows them to readily adapt to complex wound anatomies. By sustaining a moist environment, hydrofiber dressings actively support the proliferation of granulation tissue and enhance the activity of both fibroblasts and keratinocytes. For open wounds intended for secondary intention healing, they provide vital protection to the wound surface while managing exudate, thereby expediting the overall healing process (Li et al., 2024; Ndlovu et al., 2024; Ghasemi Toudeshkchouei et al., 2025).

Okra (*Abelmoschus esculentus* (L.) Moench), a member of the *Malvaceae* family, is a significant plant widely utilized in both culinary applications and traditional medicine for the treatment of various ailments. The fruit of okra is a rich source of essential vitamins and minerals, as well as natural food components possessing notable functional and biological properties. In particular, its polysaccharides, which constitute 10.38–16.89% by weight, have garnered considerable research attention. OM comprises highly viscous polysaccharides composed of L-rhamnose, L-galacturonic acid, D-glucose, and D-galactose residues. Analytical studies have identified arabinose, xylose, galactose, mannose, glucose, rhamnose, and galacturonic acid residues within dried okra extracts. The primary backbone of okra polysaccharides consists of a repeating structure of 4-α-D-galactopyranosyluronic acid and 1,2-α-L-rhamnopyranose units (Fatima et al., 2024; Kwok et al., 2025). Moreover, OM is abundant in bioactive compounds such as tannins, alkaloids, and flavonoids, which function as natural facilitators in the wound healing process (Plyduang et al., 2025). Enriched with polysaccharides, vitamins, and minerals, OM demonstrates significant biological potential, particularly in hemostatic and antioxidant activities. It is known to activate blood coagulation factors, promote their rapid release, and enhance platelet activation and adhesion, thereby facilitating the rapid formation of a hemostatic barrier at wound sites (Wang et al., 2025). Additionally, due to its rich nutritional and bioactive composition, OM exhibits pronounced healing-promoting effects (Sipahi et al., 2022; Xin et al., 2023; Zhou et al., 2025). Given these properties, OM has long attracted considerable interest in biomaterials research and is regarded as a valuable resource for potential therapeutic applications.

This study explored the incorporation of OM into commercially available wound dressings to assess its potential in promoting cell proliferation and thereby enhancing the overall biological functionality of the dressing. The objective was to gain deeper insight into the bioactive characteristics of OM, with the long-term goal of advancing its use in skin-tissue engineering and the development of next-generation wound care materials.

2. Materials and methods

2.1. Materials

Commercial hydrofiber wound dressing (Aquacel) were provided from ConvaTech, United Kingdom. Unless explicitly stated otherwise, all additional chemicals and solvents were of analytical grade and acquired from Sigma-Aldrich.

2.2. Extraction and deproteinization of OM

Okra fruits were procured from a local source. Following acquisition, they were thoroughly rinsed with water, sectioned into smaller portions, and immersed in distilled water for an extended period (overnight). The OM was subsequently isolated by passing the mixture through a muslin cloth for filtration (Nandi, 2019).

A 50% (w/v) solution of polyethylene glycol (PEG 6000) was formulated to facilitate the deproteinization procedure (Wani et al., 2023). Specifically, 50 g of PEG was completely dissolved in 100 mL of phosphate buffer maintained at pH 7.4. Equal volumes of the okra-derived mucilage and PEG solution were mixed and gently agitated to ensure homogeneity. The resulting mixture was subsequently incubated at 4 °C for 30 minutes, during which PEG acts by decreasing protein solubility, thereby promoting protein aggregation and subsequent precipitation.

After incubation, the suspension was subjected to centrifugation at 12,000 rpm for 10 minutes at 10°C. This step resulted in the sedimentation of protein aggregates as a pellet at the bottom of the centrifuge tube, while the supernatant comprised the deproteinized fraction of OM. The supernatant was carefully decanted, and mucilage were precipitated by the gradual addition of three volumes of absolute ethanol under continuous stirring. The precipitated OM were then recovered by centrifugation (Liu et al., 2024). Finally, the crude mucilage material was freeze-dried (lyophilized) to obtain a dry powder suitable for further analysis.

2.3. Obtaining Okra-enriched wound dressings

OM is integrated into commercially available wound dressings (Aquacel, ConvaTech). Briefly a 10% (w/v) OM solution was prepared in distilled water. Wound dressings, previously sectioned into 1x1 cm pieces, were then immersed in these solutions for 1 hour to facilitate absorption.

2.4. Characterization of Okra-enriched wound dressings

For the structural elucidation of the OM, commercially available wound dressings, and Okra- enriched wound dressings, Fourier Transform Infrared Spectroscopy (FTIR) was performed. A Thermo Fisher Scientific NICOLET 6700 FTIR spectrometer (Waltham, MA, USA) with attenuated total reflectance (ATR) was used for data collection, spanning wavenumbers from 400-4000 cm^{-1}.

2.5. In vitro cytotoxicity and cellular adhesion evaluation of wound dressings

2.5.1. Assessment of cytotoxicity

The *in vitro* cytotoxicity of the unmodified wound dressings and samples augmented with OM were determined using an indirect toxicity assessment method, aligning with ISO-10993-5: Biological evaluation of biomedical devices – *In vitro* cytotoxicity test (ISO 10993-5:2009, Biological evaluation of biomedical devices-chapter 5: in- vitro cytotoxicity tests.). Human epidermal keratinocyte (HaCaT) cells were employed for both cytotoxicity and adhesion investigations. HaCaT cells were cultured in Dulbecco's Modified Eagle Medium (DMEM, Biosera/France) supplemented with 10% Fetal Bovine Serum (FBS, Biosera/France) and 1% penicillin-streptomycin (Pan Biotech/Germany). Cell cultures were maintained at 37 °C in a humidified atmosphere containing 5% CO_2. Cell viability was quantified using the MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) assay (Sakarya et al., 2024). This method relies on the metabolic reduction of the tetrazolium salt by live cell mitochondria to produce insoluble purple formazan, which is then measured spectrophotometrically to determine cellular viability. For the assay, cells were seeded into 96-well culture plates at a density of 1 x 10^4 cells/well and incubated overnight to facilitate attachment. Wound dressings, including the plain wound dressing material and those enriched with OM were all prepared for extraction according to ISO-10993-12 (ISO10993-12:2021, Biological evaluation of biomedical devices-chapter 12: sample preparation and reference materials.). Samples underwent UV sterilization for 1 hour on each side, followed by submersion in DMEM at 37 °C in a 5% CO2, 95% humidity environment for 24 hours to generate 100% extracts. These extracts were subsequently diluted with DMEM and applied to the HaCaT cells. Cells cultured solely in DMEM served as the control (0% extract). All cell groups were incubated with their respective extracts for 24, 48, and 72 hours. Following the incubation period, the culture media was removed and replaced with 110 µL of MTT reagent (prepared in PBS and mixed with DMEM). After a 4-hour incubation, 100 µL of dimethyl sulfoxide (DMSO) was added to each well to dissolve the formazan crystals, and absorbance was measured at 570 nm with a 630 nm reference wavelength.

2.5.2. Investigation of cellular adhesion on wound dressings

Cellular adhesion to the wound dressings, including both the pristine dressing and the formulation enriched with OM, was assessed by direct visualization of cell attachment using scanning electron microscopy (SEM) (Thermo Fisher Quattro S). Cells were seeded at a density of 5×10^5 cells/well onto pre-sterilized, media-saturated wound dressings and incubated for 24, 48, and 72 hours. After incubation, the culture medium was aspirated, and the wound dressings were rinsed with PBS before fixation in 2.5% glutaraldehyde in PBS for 20 minutes. For SEM analysis, the wound dressings were washed with PBS and subsequently dehydrated through a graded ethanol series (70%, 80%, 90%, and 100%).

2.6. Statistical analysis

All experiments were conducted in triplicate. Data were analyzed using the non-parametric Kruskal–Wallis test, followed by Dunn's multiple comparison post-hoc test when appropriate. Statistical significance was defined as $p < 0.05$.

3. Results and discussion

3.1. Characterization

FTIR spectroscopy was conducted to characterize the commercially available wound dressing, OM-enriched wound dressing and OM. Absorbance spectra were recorded across the wavenumber range of 400-4000 cm^{-1}. The corresponding results are presented in Fig. 1.

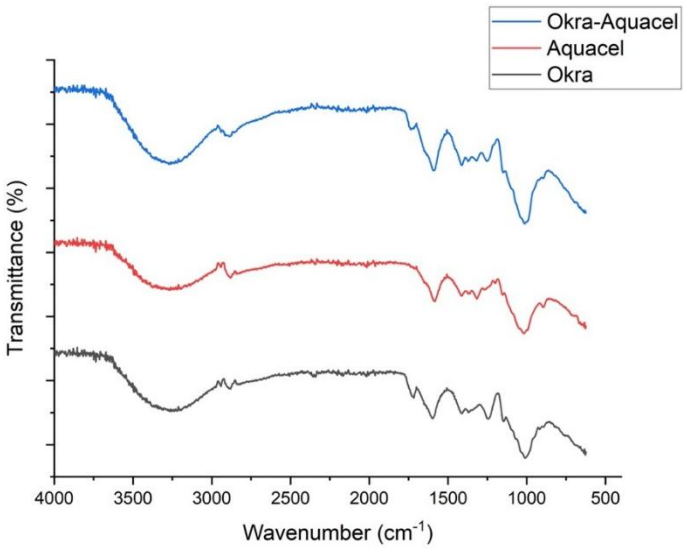


Fig. 1. FTIR spectra of commercially available wound dressing (Aquacel), OM and OM-enriched wound dressing.

In the FTIR spectrum of OM, the absorption band observed at 3252 cm^{-1} is attributed to the stretching vibrations of hydroxyl (–OH) groups. This spectral region indicates the presence of hydroxyl functionalities, which contribute to complex vibrational patterns arising from both intra- and intermolecular interactions of free –OH groups. Such features are typically associated with the amorphous structural components of carbohydrates. An absorption band observed at 1721 cm^{-1} was attributed to the stretching vibration of the ester carbonyl group. The absorption band at 1597 cm^{-1} corresponds to the asymmetric stretching vibration of carboxylate ($–COO^-$) groups and is commonly identified as part of the amide I region. Specifically, this band reflects the vibrational modes of peptide bonds and the stretching of carbonyl (C=O) groups. The band at 1412 cm^{-1} is assigned to –C–H bending vibrations characteristic of uronic acid residues, which are typical constituents of acidic polysaccharides. Due to the presence of phosphorylated polysaccharides in OM, phosphate absorption bands were observed at 1260 cm^{-1} in the FTIR spectrum. Meanwhile, the peaks appearing at 1011 cm^{-1} and 1148 $cm^{-1}$are linked to the stretching vibration of C–O–C glycosidic linkages, indicative of sugars in the pyranose configuration (de Alvarenga Pinto Cotrim et al., 2016; Zhang et al., 2020; Santos et al., 2023).

Commercially available wound dressing (Aquacel) is primarily composed of sodium carboxymethyl cellulose (NaCMC), a polysaccharide derivative known for its high absorbency and biocompatibility. In the FTIR spectrum of commercially available wound dressing, the characteristic transmission band observed at 3202 cm^{-1} corresponds to the O–H stretching vibrations associated with hydrogen bonding. The minor shoulders detected at 2922 cm^{-1} and 2872 cm^{-1} are attributed to C–H stretching modes, typically arising from aliphatic groups. A prominent and sharp absorption peak at 1587 cm^{-1} is indicative of the asymmetric stretching vibrations of the carboxylate (COO^-) group, confirming its presence. Additionally, the absorption bands located near 1410 cm^{-1} and 1319 cm^{-1} are assigned to in-plane O–H bending and C–H deformation vibrations, respectively. The FTIR spectrum of commercially available wound dressing also exhibits distinct absorption features in the 1100-1200 cm^{-1} region, corresponding to vibrational modes of the glycosidic ring and the C–O–C ether linkages, which are characteristic of the polysaccharide backbone (Kondolot Solak et al., 2016; Sorokin et al., 2021).

The OM-enriched wound dressings exhibit not only the characteristic peaks of commercially available wound dressings (Na-CMC) but also those corresponding to OM (in 1735 and 1254 cm^{-1}), indicating that the OM was successfully incorporated into the commercially available wound dressings.

3.2. In-vitro cytotoxicity and cellular adhesion evaluation of the wound dressings

3.2.1. Assessment of cytotoxicity

Cell viability was evaluated for OM-enriched wound dressing and a commercially available wound dressings after 24h, 48h, and 72 h co-incubation with keratinocytes; the results are presented in Fig. 2, Fig. 3 and Fig. 4.

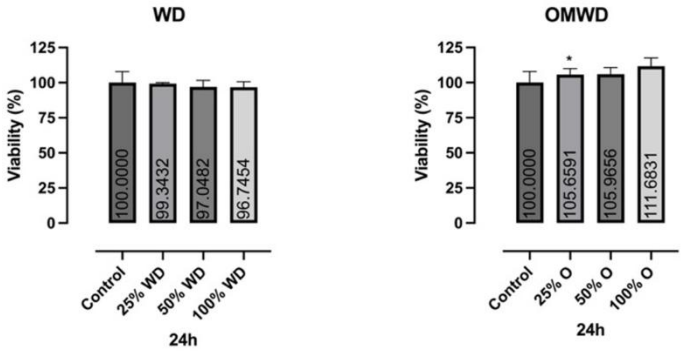


Fig. 2. Viability of HaCaT keratinocytes following 24-hour exposure to commercially available wound dressings and OM-enriched wound dressings, compared to the control group. (Differences with a *p* value less than 0.05 were considered statistically significant.)

The biocompatibility of commercially available wound dressings was found to be comparable to that of the untreated control group. In contrast, the incorporation of OM resulted in elevated cell viability after 24 hours, with recorded values of 105.66%, 105.97%, and 111.68% for the 25%, 50%, and 100% extract concentrations, respectively, relative to the control (set at 100%).

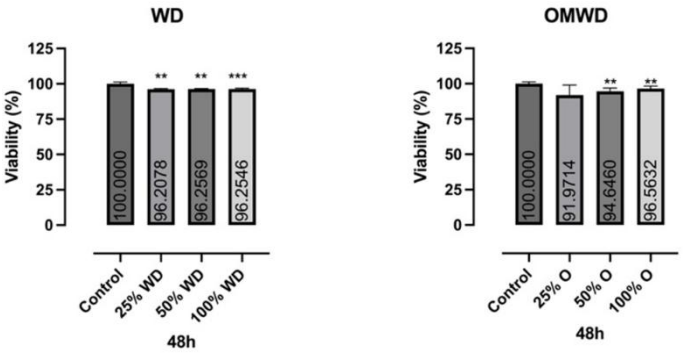


Fig. 3. Viability of HaCaT keratinocytes following 48-hour exposure to commercially available wound dressings and OM-enriched wound dressings, compared to the control group. (Differences with a *p* value less than 0.05 were considered statistically significant.)

Following 48 hours of exposure, cell viability remained enhanced for the lower concentrations, measured at 118.76% and 105.04% for the 25% and 50% extracts, while the 100% extract showed a slight decrease to 97.17%.

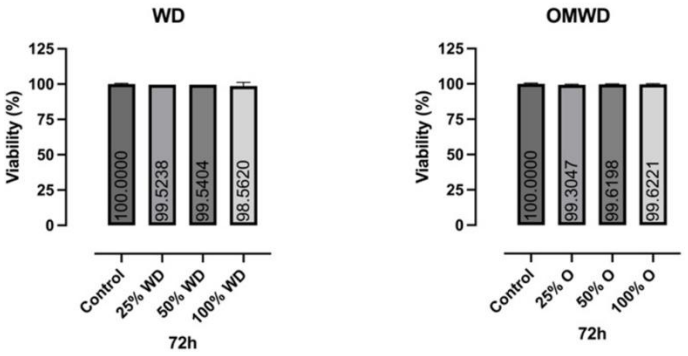


Fig. 4. Viability of HaCaT keratinocytes following 72-hour exposure to commercially available wound dressings and OM-enriched wound dressings, compared to the control group. (Differences with a *p* value less than 0.05 were considered statistically significant.)

At the 72-hour mark, viability across all concentrations stabilized near control levels, with values of 99.30%, 99.61%, and 99.62% for the 25%, 50%, and 100% extracts, respectively.

These results indicate that OM may support higher cellular viability compared to commercial dressings in the early phase (24 hours) and sustain comparable biocompatibility at extended time points (48 and 72 hours).

3.2.2. Evaluation of cell adhesion on wound dressings

Cell adhesion on the wound dressings was assessed through scanning electron microscopy (SEM). The relevant findings are depicted in Fig. 5 and Fig. 6.

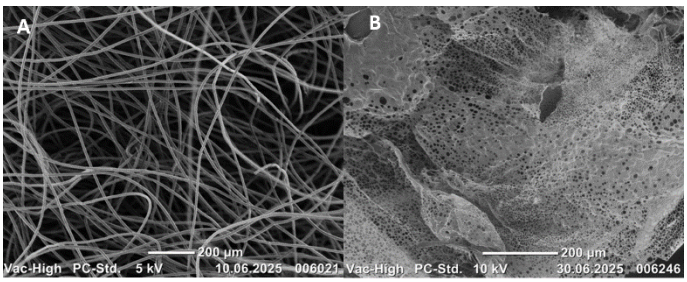


Fig. 5. Scanning electron microscopy (SEM) images of A) the unmodified wound dressing and B) the wound dressing incorporated with OM.

Cell attachment on the wound dressings was evaluated using scanning electron microscopy (SEM) (Figure 5). As shown in Fig. 5A, the wound dressing exhibited a porous structure with aligned fibers. Following enrichment with OM prior to cell seeding, an enhanced porous morphology was observed, as depicted in Fig. 5B.

The pristine wound dressing exhibits a porous and aligned fibrous structure, which is markedly altered upon OM treatment. In the treated sample, a dense and highly porous coating is observed, indicating the successful deposition of mucilage biopolymers on the fiber surfaces. This morphological modification suggests enhanced moisture retention and potential bioactivity.

Fig. 6 presents the cell adhesion behavior of wound dressings without OM (A, C, and E) and those enriched with OM (B, D, and F) after 24, 48, and 72 hours, respectively. The images clearly indicate that the incorporation of OM enhances cell adhesion. The observed trends in cytotoxicity and cell adhesion are consistent and mutually supportive. When evaluated collectively, these results demonstrate that OM promotes cell proliferation, particularly within the first 24 hours. Given that wound dressings are typically replaced at intervals ranging from 24 to 72 hours depending on the wound condition, the incorporation of OM is considered beneficial for promoting wound healing.

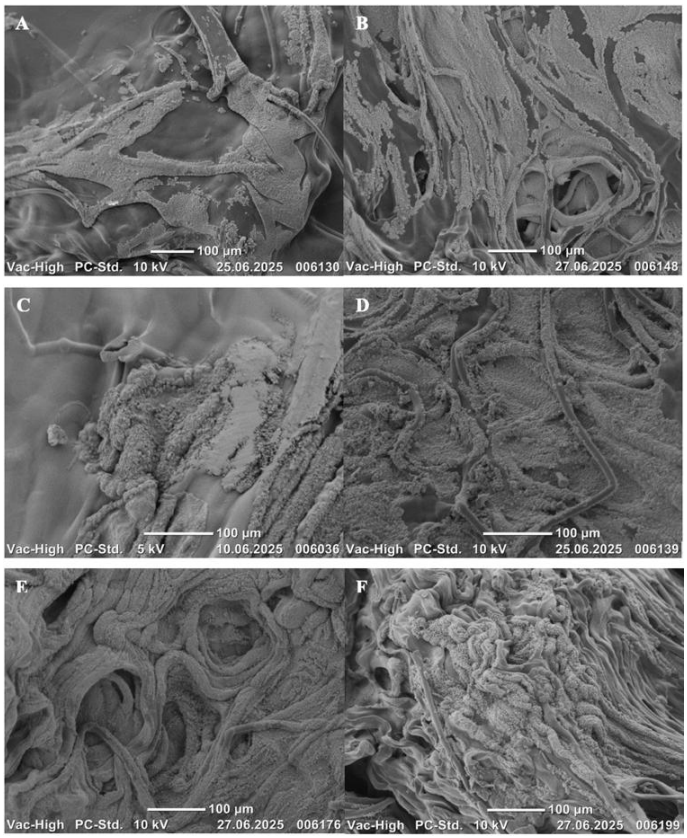


Fig. 6. SEM images of wound dressings cultivated with HaCaT cells: A, C, E) pristine; B, D, F) OM-enriched samples at 24, 48, and 72 hours, respectively.

Ilmi and colleagues examined the effects of a topical alginate-okra fruit extract formulation on wound healing in diabetic mice. Thirty-six animals were divided into twelve groups, including normal controls (NC), diabetic controls (DC), alginate-treated (DA), and alginate-okra-treated (DAO) cohorts. Wound repair was monitored at multiple time points through histopathological evaluation. The combined extract helped reduce blood glucose levels toward normal ranges following topical application, which contributed to improved healing progression. Histological assessments showed increased fibrocyte and fibroblast density and greater collagen deposition between days three and seven, along with reduced wound width and inflammatory cell presence by day 14 (Ilmi, et al., 2020). Xin and colleagues (2023) evaluated wound dressings composed of OM, obtained through different extraction methods, together with GelMA, focusing on their influence on diabetic wound healing. Okra-based preparations displayed strong biological activity and supported key processes involved in the transition from inflammation to proliferation. In vitro experiments indicated that B-OKRA, S-OKRA, and their GelMA composites enhanced cell migration and promoted vascularization, with B-

OKRA/GelMA and S-OKRA/GelMA showing the most pronounced effects. Animal studies corroborated these findings, revealing faster tissue formation, improved structural regeneration, and enhanced epithelial repair in treated groups (Xi et al., 2023). n another study, Maalej et al. (2023) produced a hydrogel using pectic polysaccharides extracted from Tunisian okra (OPS) and assessed its potential for managing chronic wounds. The hydrogel exhibited favorable physicochemical properties, high biocompatibility, and supported cell migration and proliferation without cytotoxicity. *In vivo* evaluations using a diabetic rat model demonstrated accelerated wound closure and enhanced dermal regeneration, vascular development, and granulation tissue formation, indicating that OPS-based hydrogels hold promise for chronic wound management. Zhang et al. (2025) developed a natural tissue adhesive derived from okra juice through an environmentally friendly process. The material showed strong adherence to moist tissue and markedly improved cell growth. It also reduced levels of key inflammatory markers. Both *in vitro* and *in vivo* results demonstrated faster wound closure, improved epithelial regeneration, increased vascularization, and reduced inflammation compared with commercial medical adhesives. Overall, the positive outcomes reported in the literature regarding the application of okra-derived materials to injured tissues align with the present study's findings, which show enhanced proliferation of epidermal keratinocytes.

Considering the growing body of research on the biological activities of okra-derived polysaccharides, the present study offers a clearly defined and clinically relevant contribution. Unlike previous investigations that focused on formulating entirely new okra-based hydrogels, bioadhesives, or composite scaffolds, this work demonstrates for the first time that okra mucilage can be incorporated into an existing commercial hydrofiber dressing through a straightforward immersion method. This strategy is technically advantageous because it enables functional modification of a clinically established material without altering its structural architecture, mechanical properties, or manufacturing workflow.

The marked increase in keratinocyte viability during the first 24 hours, coupled with enhanced cellular adhesion on OM-enriched surfaces, indicates that OM supports the early phase of wound healing, during which epithelial activation, cellular recruitment, and matrix–cell interactions are initiated. These observations align with previously reported pro-regenerative properties of okra-based biomaterials; however, the present study differs by demonstrating that such bioactivity can be effectively transferred onto a pre-existing hydrofiber matrix rather than requiring the development of a new material. This distinction is important because hydrofiber dressings, particularly those based on sodium carboxymethyl cellulose, are widely adopted in clinical practice due to their strong gel-forming capacity, high absorbency, conformability, and proven safety profile. These properties make them suitable candidates for modification, as their porous, hydrophilic network allows efficient uptake of OM without compromising structural integrity. By selecting a well-characterized and routinely used commercial product, this study aims to provide a practical and scalable strategy for enhancing wound-dressing functionality, thereby facilitating real-world translation rather than limiting the findings to newly engineered laboratory materials.

By confirming that OM can bioactivate a commercial hydrofiber dressing, this study helps bridge the gap between natural polysaccharide-based therapeutics and clinically used wound-care platforms. Thus, OM emerges not only as a promising component for novel biomaterial design but also as a functional additive capable of enhancing the biological performance of current dressing technologies, thereby broadening its potential for translational application.

4. Conclusion

In this study, okra mucilage was successfully incorporated into a commercially available hydrofiber wound dressing using a simple and practical immersion method, demonstrating a feasible approach for enhancing the biological performance of an existing clinical material. OM-enriched dressings promoted a clear increase in early-phase keratinocyte viability and improved cellular adhesion, indicating that OM actively supports the initial stages of wound healing rather than functioning as a passive coating. These findings distinguish the present work from previous studies that developed new okra-based hydrogels or composites by showing that the bioactive properties of OM can be effectively transferred onto a widely used wound-care platform. The results highlight OM as a promising natural additive capable of upgrading the regenerative potential of current dressing technologies. Future studies should further investigate the mechanical properties, antimicrobial activity, and *in vivo* performance of OM-modified dressings to fully define their clinical applicability.

Conflict of interest: The author declares that she has no conflict of interests.

Informed consent: The author declares that this manuscript did not involve human or animal participants and informed consent was not collected.

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