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Agro-Waste Upcycling in Wound Care: Development And Characterization of An Alkali-Treated Coconut Coir and Alginate Composite Gauze for Sustained Herbal Delivery

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Abstract: *Chronic and acute wounds place a heavy burden on patients and health systems, and conventional woven cotton gauze, although inexpensive and widely used, can adhere to the wound bed, shed lint and allow desiccation. Modern moisture-retentive dressings solve many of these problems but are costly and often non-biodegradable. At the same time, coconut (Cocos nucifera L.) processing generates very large quantities of husk that are burned or discarded.*

Coir, the lignocellulosic fibre of the husk, is porous, absorbent and biodegradable, and its properties can be improved by alkali and oxidative (H2O2) treatment. Sodium alginate, a seaweed polysaccharide that gels by ionic exchange with calcium, can be coated on a fibre matrix to create a moist, non-adherent, exudate-managing surface and a reservoir for herbal actives such as turmeric (Curcuma longa),neem, aloe vera and Centella asiatica. This review summarizes wound-healing physiology, the types of dressings, the history and limitations of gauze, the potential of agro-waste coir, the role of alginate hydrogels, and the evidence for herbal wound therapies. It then outlines a plan for developing and characterizing an alkali-treated coconut coir and alginate composite gauze for sustained herbal delivery, and identifies gaps that future work must address.

Keywords: agro-waste upcycling; coconut coir; alkali treatment; sodium alginate; herbal wound dressing; gauze; sustained release**.**

I. INTRODUCTION

1.1 Agro-waste upcycling

Agricultural wastes are the leftover organic and inorganic materials produced during the growing, harvesting and processing of crops and livestock. Upcycling, or creative reuse, converts such waste into products of higher value than the original material. In wound care, this means turning underused by-products such as fruit peels, seed extracts and plant stems or fibres into eco-friendly biomedical materials (Blasi et al., 2023). Coconut is a key crop of tropical regions, and its industrial processing leaves behind large amounts of husk. Husk is conventionally used for coir, fuel and growing media, which are low-value and unreliable outlets, so much of it is dumped or burned, wasting resources and causing pollution.

Valorisation routes such as pyrolysis, isolation and hydrolysis can convert husk into useful carbon-rich materials. Realising this at scale depends on reliable local feedstock supply, market awareness of husk-derived products, and closer links between research and commercialisation.

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1.2 Coconut coir in herbal wound healing

Coir is a natural lignocellulosic fibre with good mechanical strength, porosity, biodegradability and moisture absorption. A suitably processed coir matrix could absorb exudate, keep the wound moist, protect against external contamination and act as a carrier for the controlled delivery of herbal bioactives. Medicinal plants such as Aloe vera, Curcuma longa, Azadirachta indica and Centella asiatica have been investigated for wound-healing potential (Hemanth et al., 2025). Combining a natural fibrous matrix with a polymer such as alginate follows the logic of sustainable biocomposites, in which natural fibres are combined with a polymer matrix.



2. Wound healing Wound healing and the requirements of a dressing.

Wound healing is an intricate, coordinated process of haemostasis, inflammation, proliferation and tissue remodelling. Adequate oxygen, nutrients and an effective supply of enzymes and cells are needed for repair. Traditional dressings are widely used but may suffer from poor biodegradability, inadequate moisture control and high cost.

More than 3000 dressing products have been developed (Britto et al., 2024). Choice depends on wound depth, exudate volume, chronicity and infection. An ideal dressing should:

- protect the wound from the environment and microbial contamination;
- not adhere to the wound bed and minimise pain at changes;
- maintain a moist wound bed to support autolytic debridement;
- control exudate and protect surrounding skin from maceration;
- be cost-effective, comfortable and acceptable to patients.

3. Types of wound dressings

Dressing	Nature	Typical use
Gauze	Woven or Non- Woven absorbent fabric	This covers the early stages of more serious wounds that require packing.
Films	Thin & transparent dressings .	Superficial wounds, skin grafting, donor sites, minor wounds & intravenous sites.
Foams	Hydrophilic polyurethane , foam with or without plastic film backing.	To provide moist wound environment, most commonly in wound with moderate to heavy exudate.
Hydrogels	Water- rich hydrophilic polymers (sheets, amorphous gels).	Applied to venous or arterial ulcers and surgical wounds, protect against desiccation.
Hydrocolloids	Cross- linked hydrophilic polymers (cellulose, gelatin, pectin). Hydrocolloid are in sheets, paste, or powder form.	Pressure wounds and mild to moderate exudative wounds.
Alginates	Seaweed derived polysaccharide :Ca2+, Na+ exchange gives a gel.	Ca2+ ions have hemostatic properties. Moderate to heavy exudate, haemostatic.

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Antimicrobial	Silver or iodine impregnated.	Infected or high risk wounds.

4. Gauze

Gauze is a thin, open-mesh fabric that serves as an absorbent material, a barrier and a vehicle in topical care. It is of two main types.

Woven gauze is made of 100% purified, bleached cotton yarn and is one of the oldest dressings in use. It absorbs exudate and can pack wounds to control bleeding, but it can shed fibres (linting) that remain in the wound, and it may adhere and traumatise tissue on removal. USP classifies woven gauze by thread count (for example Type I with about 41–47 warp and 35–39 filling threads per inch, and Type VII with about 20–24 and 16–20 threads per inch, used in standard surgical pads).

Non-woven gauze is made from synthetic fibres such as rayon or polyester bonded mechanically, thermally or chemically rather than woven. It is soft, highly absorbent, low-linting and adheres less to the wound bed, making it suitable for delicate wounds, gentle cleansing and skin preparation.

Despite the benefits of moist wound healing, woven gauze remains in use in many countries as a primary contact layer. Jones (2006) traced the history of gauze and examined why moisture-retentive dressings, from the introduction of hydrocolloids onwards, did not immediately displace it, pointing to personal and organizational reasons for resistance to change. This persistence is an opportunity: an improved, low-cost gauze that addresses adherence, desiccation and drug delivery could be adopted more readily than an entirely new dressing class.

5. Coconut coir as a biomedical material

5.1 Properties and treatment

Coir fibres contain cellulose, hemicellulose and lignin, together with waxes, fats and pigments. Alkali (NaOH) treatment removes part of the lignin, hemicellulose and surface impurities, improving surface roughness, fibre–matrix interaction and hydrophilic character. Hasan et al. (2021) treated coir fibre and fibrous chips with 5% NaOH before manufacturing composite panels and characterised them by SEM, FTIR and thermal analysis, showing that treated coir can act as a reinforcing phase in engineered composites (although this was a structural,not biomedical, application).

Phowan et al. (2026) developed coconut-fibre wound dressing sheets by washing, boiling for 1 h, soaking in 10g/L NaOH for 4 h, and bleaching with 30% H2O2 for 3 h. SEM showed a thin, elongated morphology, FTIR indicated reduced lignin, hemicellulose and fat signals after the combined treatment, and the molded sheets biodegraded under simulated soil-burial conditions. The authors conclude that treated coir is a promising biodegradable material for medical dressings.

5.2 Biomedical evidence for coconut fibre

Romero Guambo et al. (2020) purified cellulose fibres from coconut and sisal for possible suture use. Coconut cellulose had a porous surface and degraded faster than sisal, neither fibre showed intrinsic antimicrobial activity, and in mice both showed scarring and mechanical connection similar to silk. Pothireddy et al. (2021) combined immature coconut fibre with tamarind seed polysaccharide and dehydrated human amnion membrane in rats and reported faster wound healing, with homogeneous collagen deposition in the test group. Ahmed et al. (2025) reported an antimicrobial dressing made from neem- and turmeric-coated coconut leaf sheath. Together, these studies support the safety and utility of coconut-derived fibres in contact with tissue, but they are few, small and preclinical, and none uses a coir–alginate gauze.

6. Sodium alginate hydrogel coatings

Alginate is a seaweed-derived polysaccharide that cross-links with Ca2+ ions to form a gel. Alginate dressings are highly absorbent, haemostatic and suited to moderate to heavily exuding wounds (Britto et al., 2024). Chen et al. (2026) reviewed sodium alginate composite hydrogels: they are easily prepared under mild conditions, can be physically or

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chemically cross-linked, and can be made antibacterial, anti-inflammatory, haemostatic and pro-angiogenic, with drug release controlled by the gel network. Reported challenges include large-scale preparation, regulatory and clinical translation barriers, limited long-term in vivo stability and limited integration of intelligent functions.

Nonglang et al. (2025) dip-coated dressings in a sodium alginate–glycerol blend containing 40% herbal extract of Kaempferia galanga or Eranthemum indicum. Excision wounds in BALB/c mice contracted more with herbal-loaded dressings (about 66–74%) than with the pristine alginate–glycerol dressing (about 52%), and the extracts gave antimicrobial efficiency against E. coli of roughly 74–96%. This is the closest precedent for the herbal-alginate coating proposed here, though the authors themselves note that further in vitro and in vivo validation is needed.

For a fibre matrix, an in-situ gel is formed by impregnating the fibre with sodium alginate and then cross-linking with CaCl2. The gel holds moisture, creates a non-adherent surface and acts as a reservoir for herbal actives, offering sustained rather than burst release.

7. Herbal agents in wound healing

Hemanth et al. (2025) reviewed herbal wound-healing agents including Aloe vera, Curcuma longa, Centella asiatica, Azadirachta indica, Calendula officinalis and Lawsonia inermis.

Flavonoids, terpenoids, alkaloids, tannins and phenolic acids contribute antioxidant, anti-inflammatory, antimicrobial and angiogenic effects, supporting collagen deposition, fibroblast proliferation, epithelialisation and wound contraction. Limitations include poor standardisation, variable plant composition, limited bioavailability and a lack of large clinical trials. Isopencu et al. (2023) similarly highlight plant gums, mucilages and secondary metabolites as biodegradable, biocompatible and cost-effective components of dermal and transdermal systems, while noting variation due to local availability and composition.

In a Azadirachta indica leaf extract Carbopol gel, Munir et al. (2021) found that the 3% w/w formulation had the best antimicrobial effect against E. coli and P. aeruginosa and the shortest epithelialisation time in rabbits (23 days against 34 days for untreated controls), illustrating a dose-dependent herbal effect. Benefits and limits of herbal dressings Potential benefits include antimicrobial, anti-inflammatory and antioxidant actions, possible haemostatic and scar-reducing effects, biodegradability, low cost where plants are locally available, and good patient acceptance. Limits include variable composition, the need for standardisation and the uneven clinical evidence, as summarised below.

Benefits and limits of herbal dressings

1. Faster healing: Herbal dressings support tissue repair and regeneration, so wounds close more quickly.
2. Infection protection: Many herbs have natural antibacterial and antifungal properties that help keep the wound clean.
3. Less pain and swelling: Their anti-inflammatory action reduces redness, swelling and discomfort.
4. Antioxidant support: They protect tissues from damage and create better conditions for healing.
5. Bleeding control and less scarring: Some herbal preparations help stop bleeding, and they encourage healthy skin regrowth, so scars are less noticeable.
6. Moist wound environment: They keep the wound moist, which speeds up recovery.
7. Safe, eco-friendly and affordable: They are biocompatible and biodegradable, usually cheaper than synthetic dressings, and carry a lower risk of side effects or allergies when properly prepared

• Comparison

Feature	Herbal dressing	Conventional dressing
Definition	Use medicinal plants or herbal extracts to treat wounds.	Uses materials such as gause , cotton, foams, films, or synthetic agents.
Main Ingredients	Plants extracts essentials oils, natural. Fibre,and herbal compounds.	Cotton, gauze, synthetic polymers, antiseptics, etc.
Main action	Healing supports, anti-inflammatory, antimicrobial.	Protection, absorption, moisture control.

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Moisture control	Formulation dependent	Generally good absorption , some may over- dry.
Environmental impact	Often biodegradable, renewable inputs.	Synthetic waste may persist.
Cost	Economical with local plants.	Varies specialized products expensive.
Clinical evidence l	Varies by herb and formulation.	Often well established.

8. Gauze-based dressings with added function

Several studies have modified gauze to add function. Sahoo et al. (2024) coated cotton gauze with a cationic chitosan derivative (HTCC), achieving about 99% bacterial reduction in 2 h, and adding dextran gave fouling resistance and prevented biofilm formation at lower bactericidal efficacy (about 90%); the gauze remained breathable and non-cytotoxic to fibroblasts. Xu et al. (2022) reported that natural brown cotton bleached gauze improved healing rate and collagen deposition in rats compared with ordinary absorbent cotton gauze. A related 2024 study of brown cotton gauze in infected wounds (Jin et al., 2024) has since been retracted and should not be relied on as evidence.

The common message is that gauze is a versatile platform and that coating or modification can convert an inert absorbent into an active dressing, which is the strategy proposed for coir.

9. Proposed development and characterisation plan

Aim: development and characterisation of an alkali-treated coconut coir and alginate composite gauze for sustained herbal delivery.

Objectives

1 Collect and prepare coconut husk fibres; treat with alkali (NaOH) to improve physical and functional properties, followed by oxidative (H2 O2) treatment to remove hydrophobic fats, waxes and pigments.

2. Quantify structural changes using FTIR (lignin and carbonyl peaks), XRD (crystallinity changes) and SEM (fibre morphology).

3. Evaluate the gauze against official monograph standards (IP/BP/USP) for absorption time, water-holding capacity, swelling index and fluorescence.

4 Form an in-situ hydrogel coating by sodium alginate impregnation followed by ionic cross-linking with CaCl2, for non-adherent moisture retention.

Plan of work: literature survey, selection of drug and raw materials, herbal extract preparation, herbal-alginate gel formulation, drying and formation of the composite gauze, evaluation (physical, mechanical, antimicrobial, swelling and absorbency tests), and compilation of work.

10. Gaps and future perspectives

• No direct precedent. Coir has been studied for sutures, sheets and composites, and alginate for herbal hydrogel coatings, but a coir–alginate herbal gauze has not been established.

• Standardisation. Herbal extracts need defined markers (for example curcuminoid content in turmeric) and batch-to-batch control.

• Sustained release. Release profiles from alginate on fibre need to be measured and correlated withantimicrobial and healing effects.

• Safety and sterility. Biocompatibility, cytotoxicity, endotoxin and sterilisation compatibility must beshown for agro-waste derived material.

• Linting and mechanical performance. Treated coir must be tested for fibre shedding, tensile strength and conformability relative to cotton gauze.

• Evidence. Most evidence is from in vitro and animal studies, so clinical validation and scale-up remain open challenges, as is also noted for alginate hydrogels (Chen et al., 2026) and herbal dressings (Hemanth et al., 2025).

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II. CONCLUSION

Alkali- and peroxide-treated coconut coir offers a low-cost, biodegradable, agro-waste-derived fibre matrix, and alginate hydrogel coatings can provide moisture retention, non-adherence and a reservoir for herbal actives. Existing studies of treated coir sheets, coconut-fibre biomaterials, herbal-alginate dressings and functionalized gauze support the feasibility of this concept, while highlighting needs for standardisation, safety testing and comparative evaluation. A coir–alginate composite gauze for sustained herbal delivery is therefore a well-motivated direction that connects waste valorisation with practical wound care.

REFERENCES

1. Ahmed, S. A., Swami, M. V., Vitthal, P. K., Palimkar, M. D., Naznin, S. I., & Pathan, M. N. (2025). Development and evaluation of an eco-friendly antimicrobial wound dressing using neem and turmeric-coated coconut leaf sheath. Journal of Pharma Insights and Research, 3(4), 318–326. https://doi.org/10.69613/rfwxvn48

2. Blasi, A., Verardi, A., Lopresto, C. G., Siciliano, S., & Sangiorgio, P. (2023). Lignocellulosic agricultural waste valorization to obtain valuable products: An overview. Recycling, 8(4), Article 61. https://doi.org/10.3390/recycling8040061

3. Britto, E. J., Nezwek, T. A., Popowicz, P., & Robins, M. (2024). Wound dressings. In StatPearls. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK470199/

4. Chen, D., He, Y., Zhang, X., Nan, L., Jin, X., Zheng, Y., Sun, C., Guo, J., & Li, X. (2026). Preparation and application of sodium alginate-based composite hydrogels in wound dressings. Gels, 12(6), Article 458. https://doi.org/10.3390/gels1206045

5. Hasan, K. M. F., Horváth, P. G., Kóczán, Z., & Alpár, T. (2021). Thermo-mechanical properties of pretreated coir fiber and fibrous chips reinforced multilayered composites. Scientific Reports, 11, Article 3618. https://doi.org/10.1038/s41598-021-83140-0

6. Hemanth, K., et al. (2025). [Herbal wound-healing review; complete author list and title to be verified]. GSC Biological and Pharmaceutical Sciences, 33(2). https://doi.org/10.30574/gscbps.2025.33.2.0470

7. Isopencu, G. O., Covaliu-Mierl■, C.-I., & Deleanu, I.-M. (2023). From plants to wound dressing and transdermal delivery of bioactive compounds. Plants, 12(14), Article 2661. https://doi.org/10.3390/plants12142661

8. Jin, S., Jin, Z., Zhou, W., Jin, J., Sun, Y., & Jin, Z. (2024). A study of the effect of natural brown cotton gauze on the healing of infected wounds. Skin Research and Technology, 30(6), Article e13778. https://doi.org/10.1111/srt.13778. [Retracted 2025)

9. Jones, V. J. (2006). The use of gauze: Will it ever change? International Wound Journal, 3(2), 79–88. https://doi.org/10.1111/j.1742-4801.2006.00215.x

10. Munir, M., Shah, S. N. H., Almas, U., Khan, F. A., Zaidi, A., Bukhari, S. M., & Murtaza, G. (2021). An assessment of the wound healing potential of a herbal gel containing an Azadirachta indica leaf extract. Veterinární Medicína, 66(3), 99–109. https://doi.org/10.17221/46/2020-VETMED

11. Nonglang, F. P., Verma, C., Gupta, B., Wankhar, W., & Bhan, S. (2025). Preparation of a novel sodium alginate-glycerol herbal Kaempferia galanga and Eranthemum indicum coated dressings for wound care. Vegetos. https://doi.org/10.1007/s42535-025-01485-7

12. Phowan, N., Nooeaid, P., & Kaewphinit, T. (2026). Characteristics and performance analysis of a natural medical bandage prepared from coconut fiber. Textile Research Journal. https://doi.org/10.1177/00405175251385552

13. Pothireddy, R. B., Julius, A., Mathai, M. T., Lakshmanan, G., & Hailemariam, B. A. (2021). A combination of coconut fiber suture and tamarind seed gel with dehydrated human amnion membrane for wound surgery in rats. Advances in Materials Science and Engineering, 2021, Article 8122989. https://doi.org/10.1155/2021/8122989

14. Romero Guambo, M. P., et al. (2020). [Cellulose fibres from coconut and sisal for surgical sutures; complete author list and title to be verified]. Polymers, 12(12), Article 3042. https://doi.org/10.3390/polym12123042

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International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
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15. Sahoo, M., Paul, M., Kothari, P. P., Varanasi, M., Biswas, S., & Mitra, D. (2024). Polysaccharide-modified bactericidal and fouling-resistant cotton gauze for potential application as a wound dressing. Carbohydrate Polymer Technologies and Applications, 7, Article 100437. https://doi.org/10.1016/j.carpta.2024.100437
16. Xu, J., Su, M., Jin, Z., Zhou, W., Sun, Y., Jin, Y., & Shi, Z. (2022). Effects of natural brown cotton bleached gauze on wound healing. Materials, 15(6), Article 2070. https://doi.org/10.3390/ma15062070