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Preparation and evaluation of wound healing gel from marine sea weed - "Fucoidan"

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Abstract
Wound healing is a complex biological process involving tissue repair and regeneration. Natural and marine-derived biomaterials have gained considerable attention in wound-care formulations because of their biocompatibility and biological properties. The present study was undertaken to prepare and evaluate a topical wound healing gel containing fucoidan, Aloe vera and chitosan. Fucoidan, a sulphated polysaccharide obtained from brown seaweed, possesses reported anti-inflammatory, antimicrobial and wound-healing-related biological activities. Aloe vera provides moisturizing, soothing and tissue-supporting properties, while chitosan is a biocompatible polymer with film-forming and antimicrobial properties.
The gel formulation was prepared using sodium carboxymethyl cellulose as the gelling agent, along with glycerin, methylparaben and purified water. The prepared formulation was evaluated for physical appearance, viscosity, pH, spreadability, extrudability, homogeneity, absence of specific pathogenic microorganisms, moisture retention capacity and antimicrobial activity. The formulated gel showed a smooth and uniform appearance, a viscosity of 485 cP, pH of 5.0, spreadability of 7.5 g·cm/sec and moisture retention capacity of 90%. The formulation also demonstrated antimicrobial activity against Escherichia coli, with zones of inhibition of 24 mm and 21 mm at 75 µL and 50 µL, respectively.
The formulation exhibited satisfactory physicochemical characteristics and antimicrobial activity and may have potential for topical wound-care applications. However, experimental wound-healing activity was not performed in the present study; therefore, further in-vitro and in-*vivo* studies are required to establish its actual wound-healing efficacy.

Keywords: Fucoidan, marine seaweed, wound healing, Aloe vera, chitosan, sodium carboxymethyl cellulose, topical gel, antimicrobial activity

Introduction
A wound is a disruption or break in the normal anatomical structure and function of the skin or underlying tissues caused by physical, chemical, thermal or microbial injury. Wound healing is a complex biological process involving a series of coordinated events including haemostasis, inflammation, proliferation and tissue remodelling.
Wounds may be broadly classified into acute and chronic wounds. Acute wounds include surgical incisions and traumatic injuries, whereas chronic wounds such as diabetic ulcers, pressure ulcers and venous ulcers may fail to progress through the normal stages of healing.
The conventional management of wounds includes wound dressings, antimicrobial therapy and advanced therapeutic approaches. Conventional dressings such as gauze and cotton pads protect the wound from external contamination and absorb exudates, but they may adhere to the wound surface and may not maintain an optimal moist environment. Advanced wound dressings such as hydrocolloids, hydrogels, alginate dressings and foam dressings are designed to provide a moist wound environment and support tissue repair.
Topical gel formulations have gained attention in wound management because they are easy to apply, provide a moist environment and allow uniform distribution of active substances over the affected area. Gels are semi-solid dosage forms consisting of a three-dimensional polymeric network capable of retaining water or biological fluids.
Natural products and marine-derived biomaterials are increasingly investigated for wound-care applications. Marine organisms such as algae and crustaceans provide bioactive materials including polysaccharides and proteins. Fucoidan, alginate and chitosan are among the marine-derived biomaterials investigated for biomedical applications.
Fucoidan is a sulphated polysaccharide obtained mainly from brown seaweed. It has reported anti-inflammatory, antimicrobial and antioxidant activities and has been investigated for its possible role in angiogenesis, fibroblast proliferation and collagen synthesis. Aloe vera is widely used in topical preparations because of its moisturizing, soothing, anti-inflammatory and wound-supporting properties. Chitosan is a natural biopolymer with biocompatibility, biodegradability, film-forming and antimicrobial properties.
Based on these properties, the present study focused on the preparation and quality evaluation of a topical gel containing fucoidan, Aloe vera and chitosan.

Aim and Objectives
- To develop a marine-derived topical gel formulation containing fucoidan, Aloe vera and chitosan for wound-care applications.
- To prepare a topical wound-care gel containing marine-derived fucoidan along with Aloe vera and chitosan.
- To select suitable excipients for the preparation of a stable gel formulation.
- To standardize the selected raw materials.
- To evaluate the prepared gel using suitable physicochemical and microbiological parameters.
- To determine the antimicrobial activity of the formulated gel.

Method of Preparation

Sodium carboxymethyl cellulose was dispersed in purified water and allowed to hydrate adequately to form the gel base. Chitosan was dissolved in dilute acetic acid solution. Fucoidan was dissolved in a suitable solvent and incorporated into the formulation. Aloe vera gel was then added and mixed thoroughly. The ingredients were combined under continuous stirring to obtain a uniform preparation. Triethanolamine was added, if required, for pH adjustment, followed by incorporation of methylparaben as preservative. The final formulation was mixed until a homogeneous gel was obtained.

Formulation

Ingridient	Quantity	Function
Fucoidan	0.15g	Active ingridient
Aloe vera gel	0.75g	Active ingridient
chitosan	0.30g	Active ingridient
Sodium carboxy methyl cellulose	0.075g	Gelling agent
glycerin	0.30g	Humectant
triethanolamine	Q.S.	pH adjuster if needed
Methyl paraben	0.015 g	Preservative
Purified water	Q.S. to 15g	Vehicle

Standardization of Raw Materials

Organoleptic Evaluation

Fucoidan, Aloe vera and chitosan were examined for colour, odour and appearance.

Fucoidan was observed as a brown to dark-brown fine powder with a characteristic marine seaweed odour. Aloe vera was observed as a colourless to pale-green translucent viscous gel with a mild characteristic odour. Chitosan was observed as an off-white to cream fine powder with faint characteristic odour.

Identification Tests

Fucoidan was dissolved in water and treated with dilute hydrochloric acid followed by barium chloride. White turbidity/precipitate was observed, indicating the presence of sulphate-containing polysaccharide.

Aloe vera was identified based on its characteristic translucent gel-like appearance and properties.

Chitosan was treated with 1% acetic acid and stirred. It dissolved/dispersed to form a clear to slightly opalescent viscous solution, supporting its identification based on characteristic solubility in dilute acid.

Purity Evaluation

The raw materials were visually examined for foreign matter and visible impurities. No visible foreign matter was observed.

Moisture Content

Moisture content was determined by weighing the sample, drying it to constant weight and calculating the percentage loss in weight.

The reported moisture content was:

Fucoidan – 8.2% w/w

Aloe vera gel – 14.6% w/w

Chitosan – 7.5% w/w

Phytochemical/Bioactive Constituents

The major reported bioactive constituents of the selected materials were reviewed from published literature. Fucoidan contains sulphated polysaccharides, Aloe vera contains acemannan and other bioactive constituents, and chitosan is a bioactive polysaccharide with reported antimicrobial and wound-care-related properties.

Evaluation of Formulated Gel

Physical Appearance

The prepared gel was visually examined for colour, odour, texture and presence of lumps or foreign particles.

Result: The formulation was light brownish-green in colour, had a characteristic odour and showed a smooth and uniform texture. No visible foreign particles were observed.

Viscosity

The viscosity of the prepared gel was determined using a Brookfield viscometer at room temperature.

Result: The viscosity of the formulated gel was 485 cP.

pH

The pH of the gel was determined using pH indicator paper after dispersing a small quantity of the formulation in distilled water.

Result: The pH of the formulated gel was **5.0**.

Spreadability

Approximately 2 g of gel was placed between two glass slides. A weight was placed over the upper slide and the time required for movement through a distance of 7.5 cm was recorded.

Spreadability was calculated using:

$S = M \times L / T$

Result: The spreadability of the formulated gel was 7.5 g·cm/sec.

Extrudability

The formulated gel was filled into a collapsible tube and gently pressed to evaluate the ease and uniformity of extrusion.

Result: The gel was easily extruded from the tube with slight pressure and showed good extrudability.

Homogenecity

The formulation was examined for uniformity of colour and consistency and for the presence of lumps, aggregates and foreign particles.

Result: The gel was smooth and uniform and showed good homogeneity.

Test for Specific Pathogenic Microorganisms

The formulated gel was examined using appropriate microbiological procedures to determine the absence of specific pathogenic microorganisms.

Result: No growth of the tested specific pathogenic microorganisms was observed.

Moisture Retention Capacity

A known quantity of gel was weighed and allowed to stand under the specified conditions. The sample was weighed again and moisture retention capacity was calculated.

Initial weight - 2.0 g

Final weight -1.8 g

Moisture retention capacity - 90%

Moisture retention capacity (%) = Final weight / Initial weight × 100

Result: The formulation showed a moisture retention capacity of 90%.

Test for Antimicrobial Activity

The antimicrobial activity of the formulated gel was evaluated by the agar well diffusion method using Escherichia coli on Mueller–Hinton Agar. The zone of inhibition was measured in millimetres.

Sample	Zone of inhibition
standard	31mm
75µL[higher concentration]	24mm
50µL[lower concentration]	21mm

The formulation demonstrated antimicrobial activity against E. coli. The 75 µL sample showed a zone of inhibition of 24 mm, while the 50 µL sample showed 21 mm. The standard showed a zone of inhibition of 31 mm.

Results and Discussion

The prepared marine-derived gel containing fucoidan, Aloe vera and chitosan showed satisfactory physical characteristics. The formulation was smooth, uniform and free from visible foreign particles. The viscosity of 485 cP indicated suitable consistency for topical application, while the pH of 5.0 was within an acidic range relevant to topical preparations.

The formulation showed a spreadability of 7.5 g·cm/sec and good extrudability, indicating ease of application and removal from the container. Good homogeneity was observed without lumps or aggregates. The moisture retention capacity was found to be 90%, demonstrating the ability of the formulation to retain moisture.

The antimicrobial study showed inhibition of E. coli, with zones of inhibition of 24 mm and 21 mm for 75 µL and 50 µL samples, respectively. The observed antimicrobial activity supports the potential usefulness of the formulation in wound-care applications. However, antimicrobial activity alone does not establish wound-healing efficacy.

Conclusion

The present study involved the preparation and evaluation of a marine-derived topical gel containing fucoidan, Aloe vera and chitosan using sodium carboxymethyl cellulose as the gelling agent. The formulation exhibited satisfactory physical appearance, homogeneity, viscosity, pH, spreadability and extrudability. The formulation also demonstrated 90% moisture retention capacity and antimicrobial activity against Escherichia coli.

The findings indicate that the prepared formulation possesses satisfactory physicochemical and antimicrobial characteristics and may have potential as a topical wound-care formulation. However, experimental wound-healing activity was not performed in the present study. Therefore, further in-vitro and in-*vivo* investigations are necessary to establish the actual wound-healing efficacy and safety of the formulation.

Future Studies

Further studies may include:

In-vitro wound-healing studies such as scratch assays to evaluate cell migration and wound closure.

In-*vivo* studies using suitable animal models to assess wound contraction and healing rate.

Histopathological studies to investigate tissue regeneration, collagen formation and re-epithelialization.

Molecular docking studies to investigate possible interactions between selected bioactive compounds and wound-healing-related target proteins.

Long-term stability studies under suitable storage conditions.

Further optimization of the formulation to establish its safety, efficacy and therapeutic potential.

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