CrabCare: Innovative Chitosan Biopolymer-Based Ointment from Crab Shell Waste by Utiling

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Abstract. Wounds are a common problem that requires effective care to prevent infection and accelerate the healing process. The use of conventional antiseptics is often unsatisfactory due to the long time required. Therefore, the innovation of using chitosan from crab shell waste as a base material for ointment becomes the focus of this research. This study aims to develop a chitosan-based ointment that can accelerate the wound healing process more efficiently. The research results show that the ointment developed from crab shells through the deproteinization process can significantly accelerate wound healing. Chitosan extracted from crab shells has unique properties such as bioactivity, biodegradability, and biocompatibility, which are effective in inhibiting bacterial and pathogen growth, as well as stimulating granulation tissue formation. Thus, the CrabCare ointment made from crab shell chitosan offers a promising alternative as a therapeutic agent for more effective and environmentally friendly wound care. In conclusion, the development of CrabCare provides new opportunities in wound therapy through innovative and sustainable means.

1 Introduction

Wounds are a common condition in the human body and require optimal care to minimize the risk of infection and accelerate the healing process [1]. The prevalence of wounds in the community is very high, but the use of antiseptics in their treatment tends to take a long time and is not fully satisfactory [2]. Mackerel shells, which have been considered as waste from the fishing industry, have great potential as a source of bioactive ingredients that can be utilized for medical purposes [3–8]. Chitosan is a biopolymer produced through the deacetylation process of chitosan, which is also present in the shells of insects and fungi [9]. This biopolymer is known to have very favorable properties in medical applications, such as bioactive, biodegradable, and biocompatible [10,11].

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As a therapeutic agent, chitosan has been proven effective in accelerating the wound healing process [12]. Chitosan is able to inhibit the growth of pathogenic bacteria and promote granulation tissue formation, which is essential in the regeneration process of damaged tissues [8,13,14] In addition, its biodegradable nature and compatibility with the human body make chitosan an ideal choice for base material in ointment formulations [6,15–19] One of the latest innovations in the utilization of chitosan is the development of CrabCare ointment, which utilizes chitosan extracted from crab shells. This CrabCare ointment is designed to accelerate wound healing in a more efficient manner compared to conventional antiseptics. The deproteination process of the shells produces chitosan that can be used as an ointment base that has natural antibacterial ability and accelerates the healing process [20,21]

This study aims to explore the potential of CrabCare ointment based on chitosan from catfish shells in accelerating wound healing. The focus of this research is to understand how this ointment can inhibit the growth of pathogenic microorganisms and stimulate tissue regeneration, thus providing a more effective and environmentally friendly wound care solution. By developing biopolymer-based therapeutic products such as CrabCare, it not only provides an innovative solution in wound care but also utilizes the abundant waste of crab shells and can have a positive impact on the environment. This research is expected to pave the way for the development of sustainable and environmentally friendly medical products, which provide real benefits in the field of healthcare.

2 Method

This research is an experimental study conducted using the isolation method and activity testing of chitosan from crab shells. The sample collection took place in Dompak, Tanjungpinang. The processing and procedures, such as deproteinization, demineralization, and characterization, were carried out at the Chemistry Laboratory of Universitas Maritim Raja Ali Haji. The following are the methodologies used in this research.

2.1 Materials

Fresh crab shells (source: Seafood Restaurant Tanjungpinang, Indonesia), 5% Sodium hydroxide (NaOH), 1N Hydrochloric acid (HCl), Distilled water.

2.2 Equipment

Analytical balance, beaker, watch glass, drying oven, blender or grinder, centrifuge, ph meter, graduated cylinder, stirring rod, filter paper, glass funnel, wire gauze, magnetic stirrer, uv-vis spectrophotometer, infrared spectroscopy. Chitosan Extraction Process from Crab Shells.

2.3 Deproteinization

Deproteinization is the process of removing proteins from crab shells to obtain pure chitin. This process is the first step in converting crab shells into chitosan. The purpose of deproteinization is to eliminate proteins from the crab shells. The procedure is carried out as follows: Fresh crab shells are washed with clean water to remove any remaining soft tissues and impurities. The shells are then dried in an oven at 60°C for 24 hours. Once dried, the shells are ground into a fine powder using a mortar and pestle. 100 g of crab shell powder is weighed and mixed with a 5% NaOH solution in a 1:10 ratio. The mixture is heated at 90°C for 2 hours, with gentle stirring to ensure an even reaction. After the process

is complete, the mixture is cooled to room temperature and filtered to separate the liquid from the solid. The obtained solid is washed repeatedly with distilled water until it reaches a neutral pH (pH 7), and then dried again in the oven at 100°C for 2 hours.

2.4 Demineralization

Demineralization is a critical step in ensuring that the obtained chitin is free from mineral contaminants, which can affect the quality and purity of chitosan. This process also ensures that the biopolymer properties of the resulting chitosan meet the standards for use as a therapeutic agent in wound healing ointments. Proper demineralization yields chitin with a better structure, making it easier to convert into chitosan with optimal physical and chemical properties for medical applications. The deproteinized powder is weighed to 10 g and mixed with 1N HCl solution in a 1:10 ratio in a beaker. The mixture is stirred at room temperature for 30 minutes. The mixture is then filtered to separate the liquid from the solid. The obtained solid is washed with distilled water until it reaches a neutral pH and then dried again in an oven at 100°C for 2 hours. The resulting powder after demineralization is chitin.

2.5 Conversion of Chitin into Chitosan

The deacetylation process of chitin into chitosan is carried out as follows: The obtained chitin is weighed to 10 g and mixed with a 50% NaOH solution in a 1:10 ratio. The mixture is heated at 100°C for 2 hours, with gentle stirring. After the process is complete, the mixture is cooled, then filtered and washed with distilled water until it reaches a neutral pH. The solid chitosan is dried in an oven at 100°C for 2 hours. The dried chitosan is ground into a fine powder and stored in a sealed container for future use.

2.6 Chitosan Ointment Preparation

The chitosan ointment is prepared using the following formulation: 2 g of chitosan powder is mixed with vaseline in ratios of 1:2 and 2:1. The mixture is stirred until a homogeneous ointment is formed. The ointment is then packaged in a sterile container.

2.7 Chitosan Characterization Analysis

Chitosan characterization is performed to ensure its quality and purity. The analysis is conducted using UV-Vis Spectrophotometry: UV-Vis analysis is carried out to determine the concentration of dissolved chitosan. The absorbance of the chitosan solution is measured at a wavelength of 280 nm to assess residual protein content.

2.8 Chitosan Ointment Effectiveness Test

The effectiveness test of the ointment is conducted by observing wound reactions on the skin. This test ensures that the product is safe for use on human skin. The skin's reaction to the ointment can indicate whether any ingredients may cause irritation, allergies, or other side effects. This is crucial to prevent negative impacts on users. CrabCare ointment will be tested on various skin types, including sensitive, normal, and oily skin. This testing is done to ensure no adverse reactions occur when the ointment is applied to skin with different characteristics.

3 Results and Discussion

In this section, data comparing the degree of deacetylation of chitosan extracted from mangrove crab shells and regular crab shells will be presented and analyzed. The degree of deacetylation is a key parameter that influences the physicochemical properties of chitosan, including solubility, viscosity, and biological activity. This will be followed by the results of chitosan isolation from crab shells using FT-IR analysis.

Table 1. Degree of Deacetylation (DD) of Standard Chitosan and Isolated Mangrove Crab Chitosan Samples

No	Sample Degree	Deasetilasi (%)
1	Standard Chitosan (*Sigma*)	55.29
2	Isolated Chitosan	59.39

The data shows that the chitosan extracted from mangrove crab shells has a degree of deacetylation of 59.39%.

Table 2. Degree of Deacetylation (DD) of Standard Chitosan and Isolated Crab Shell Chitosan Samples

No	Sample Degree	Deasetilasi (%)
1	Standard Chitosan (*Sigma*)	55.29
2	Isolated Chitosan	80.05

The unique recent findings from this research contribute to the field of science by demonstrating that chitosan extracted from crab shell waste has a degree of deacetylation of 80.05%. The optimal deacetylation standard for chitosan from crab shells is between 70% and 90%. This degree of deacetylation is important as it affects the physical and chemical properties of chitosan, such as solubility, viscosity, and bioactivity.

3.1 Low Degree of Deacetylation (<70%)

At this level, chitosan has lower solubility and may be less effective in applications requiring high solubility in water, such as medical or pharmaceutical applications. The degree of deacetylation is one of the key parameters in characterizing chitosan obtained from the deacetylation process of chitin. Deacetylation refers to the removal of acetyl groups from chitin to produce chitosan. A low degree of deacetylation indicates that only a small portion of the acetyl groups has been removed, resulting in chitosan with different properties compared to chitosan with a high degree of deacetylation. Chitosan with a low degree of deacetylation tends to have lower solubility in acidic solutions compared to chitosan with a high degree of deacetylation. This is due to the lack of free amino groups that enhance solubility in acidic media.

3.2 Medium Degree of Deacetylation (70%-90%)

This range is commonly desired for most applications because chitosan within this range strikes a good balance between solubility and viscosity, as well as optimal bioactive properties [22–24]. The degree of deacetylation (DA) refers to the percentage of acetyl groups that have been removed from chitin to produce chitosan. Chitosan with a medium

degree of deacetylation (70%-90%) indicates that most acetyl groups have been removed, but some acetyl groups still remain.

3.3 High Degree of Deacetylation (>90%)

Chitosan with a very high degree of deacetylation has excellent solubility in mild acidic solutions; however, its viscosity may become very high, which can affect certain processing and application methods [25,26]. Chitosan with a high degree of deacetylation (>90%) means that most of the acetyl groups have been removed from chitin, resulting in chitosan with a very high proportion of free amino groups. A high degree of deacetylation gives chitosan superior physical, chemical, and biological properties, making it highly effective for various applications, including as an active ingredient in wound healing ointments like CrabCare.

Thus, the optimal deacetylation standard for chitosan from crab shells generally falls within the range of 70% to 90%, depending on the specific needs of the desired application.

3.4 Results of Chitosan Isolation from Crab Shells Using FT-IR

The results of chitosan isolation from crab shells analyzed by FT-IR can be seen in Figure 1.

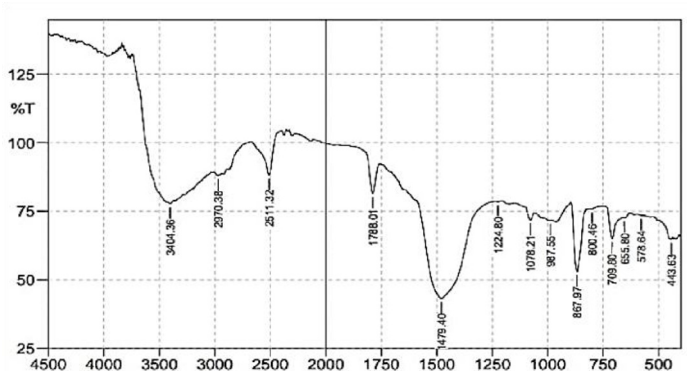

Fig. 1. Chitosan isolation from crab shells analyzed by FT-IR

The comparison of the infrared spectra of the isolated chitosan and standard chitosan shows that the functional groups in the samples are not significantly different from the standards at each wavenumber. Therefore, it can be concluded that the compounds produced from these crab shells yield chitin and chitosan that meet the standards, as shown in Table 3.

Table 3. Standard Chitosan and Isolated Chitosan

No.	Type of Vibration	WaveNumber (cm^{-1})	
		Standard Chitosan	**Isolated Standard Chitosan** [27]
1.	Overlapping O-H Bending Vibration and N-H Stretching Vibration	3421.72	3404.36
2.	Aliphatic C-H Symmetrical Stretching Vibration	2881.65	2970.38
3.	C=O Stretching Vibration	1651.07	1788.01
4.	C-H Stretching Vibration	1423.47	1479.40
5.	C-O Stretching Vibration	1253.73	-
6.	Symmetrical C-N Stretching Vibration	1145.72	-
7.	C-O-C Stretching Vibration	1068.56	1078.21
8.	β-1,4-Glycosidic Stretching Vibration	898.83	867.97

The comparison of wavenumbers between standard chitosan and isolated chitosan shows that the majority of the main functional groups are identified in the spectra of both samples. This includes vibrations relevant to hydroxyl (-OH), amino (-NH), carbonyl (C=O), aliphatic C-H, and glycosidic bonds (C-O-C and β-1,4-glycosidic).

3.5 Safety Test Results

In the effectiveness test results for the reaction of the ointment on the skin of several samples, no irritation, allergy, or other side effects were found on all types of skin tested. These results indicate that CrabCare ointment is safe for use on various skin types without causing dermatological issues. The absence of negative reactions such as redness, itching, or swelling suggests that the ingredients used in CrabCare ointment do not cause irritation or allergies. The use of natural ingredients, such as chitosan from crab shells that have undergone proper deproteinization and demineralization processes, contributes to the safety profile of this ointment.

3.6 Testing of Organoleptic Physical Properties of Conventional Ointment and CrabCare Ointment

Organoleptic testing was conducted visually by assessing the color, odor, and form of the Conventional Ointment and CrabCare Ointment. The results of the organoleptic tests can be seen in Table III.

Table 4. Results of Organoleptic Testing of Conventional Ointment and CrabCare Ointment

Formulation	Color	Odor	Form
Conventional Ointment	Brownish White	Characteristic	Semi-solid
CrabCare Ointment	Brownish White	Characteristic	Semi-solid

The observations from the organoleptic testing of the Conventional Ointment and CrabCare Ointment in Table IV show that both formulations exhibit a brownish-white color. This color results from the addition of chitin from crab shells, indicating consistency in the coloration produced by the incorporation of chitin. The scent produced by CrabCare Ointment is a characteristic odor of crab shells, which originates from the natural chitin used in the formulation. Both the Conventional Ointment and CrabCare Ointment have a semi-solid form, aligning with the general characteristics of ointments, making them easy to apply and adhere well to the skin.

4 Conclusion

This study explores the significant potential of the biopolymer chitosan derived from crab shells as a therapeutic agent in the development of ointments for wound healing acceleration. The research findings indicate that chitosan from crab shells possesses bioactive, biodegradable, and biocompatible properties that significantly support the wound healing process. Utilizing chitosan as a base for ointments not only speeds up wound healing by inhibiting the growth of bacteria and pathogenic microorganisms but also reduces inflammation and promotes the proliferation of new granulation tissue. The chitosan-based ointment developed in this study demonstrates high efficacy in accelerating wound healing. This proves that crab shells, often regarded as waste, can be processed into high-value products beneficial in the health sector. The utilization of crab shells also presents an innovative and environmentally friendly solution by reducing marine waste and positively impacting the local economy through the empowerment of abundant natural resources in Indonesia. By integrating chitosan as a primary ingredient in ointments, this research not only provides an alternative solution for wound care but also represents a step forward in holistic wound treatment. The antimicrobial and anti-inflammatory properties of chitosan, along with its ability to stimulate tissue regeneration, make it a superior therapeutic agent for accelerating the wound healing process. This research indicates that the use of chitosan-based ointments could become a new standard in wound care, offering a more effective, safe, and environmentally friendly solution. With further support in research and development, the innovation of chitosan ointments from crab shells could have widespread positive impacts, not only on individuals receiving treatment but also on society as a whole. Optimizing the potential of chitosan biopolymer from crab shells is an important and strategic step in investing in the health and well-being of the community.

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