Research Article
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Potential of Chitosan from Mangrove Snail Shells (*Telescopium* sp.) in Body Scrub Formulation

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Abstract: Mangrove snails (*Telescopium* sp.) are a potential source of chitin-rich shells, which can be converted into chitosan with antimicrobial, humectant, and natural thickening properties suitable for cosmetic applications. This study aimed to evaluate the effect of varying chitosan concentrations on the quality and shelf life of body scrubs and to identify the optimal concentration for formulation. An experimental approach was employed, assessing chitosan characteristics (yield, moisture content, ash content, nitrogen content, and degree of deacetylation) and product quality parameters (homogeneity, humectant capacity, viscosity, adhesiveness, spreadability, pH, total bacterial count, and total fungal count) over a 30-day storage period. Chitosan derived from mangrove snail shells showed a yield of 9.91%, with 6.10% moisture, 6.34% ash, 6.57% nitrogen, and 67% degree of deacetylation. The 2% chitosan formulation yielded the best results, with favorable humectant capacity (94.75%), viscosity (3746.05 cps), adhesiveness (6.12 s), spreadability (6.52 cm), pH (6.38), and low microbial counts (10^3 CFU). Chitosan's antimicrobial activity contributed to maintaining product quality and safety throughout the 30-day shelf life.

Introduction

Riau Province has 224,895 hectares of mangrove forests, making it the third-largest mangrove forest area in Indonesia. A total of 30,113 hectares of these mangrove forests are located in Meranti Islands Regency (1). These mangrove forests provide habitat for a variety of biota, such as mangrove plants, reptiles, birds, fish, crustaceans, and mangrove snails (*Telescopium* sp.). The population of mangrove snails in the study area varied between 3 and 350 individuals per 100 square meters, depending on the location and time of observation. Mangrove snails utilize mangrove ecosystems as feeding and breeding grounds (2).

The Meranti Islands have experienced an increase in mangrove snail fishing with a catch of around 200 kg per day in shelled condition (3). Local communities utilize mangrove snails as side dishes and animal feed. In addition, mangrove snails also act as biofilters in pond waste management, indicating the potential for wider utilization of these biota. The utilization of mangrove snail shells is still not optimal, even though mangrove snail shells contain chitin of as much as 20% of body weight, which can be processed into chitosan of about 8.5% (4). Snail shells contain approximately 20% chitin by body weight, which can be converted into chitosan with functional properties such as water-binding capacity, emulsion stabilization, and antimicrobial activity. Compared to conventional sources like shrimp or crab, snail shell-derived chitosan offers a locally available and sustainable alternative, making it highly promising for eco-friendly and economically viable applications in the natural cosmetics industry. Chitosan and its derivatives are widely used in the pharmaceutical and beauty industries as humectants, thickeners, stabilizers, and moisturizers, and have antimicrobial and preservative properties. The advantages of chitosan as an active ingredient are non-toxic, easily biodegradable, and polyelectrolytic (5).

Body scrubs are beauty products used to smooth the skin and regenerate dead skin cells with the help of coarse particles as sanders (6). Typically, body scrubs are made of emulsion paste containing synthetic scrubbingagents such as polyethylene or natural agents such as apricot kernels and almonds. These products also contain chemicals such as methyl parabens as preservatives, which if used in higher concentrations (>0.4%) can be harmful to health (7). Chitosan, a natural ingredient that has emulator, humectant, and antimicrobial properties, has the potential to replace these chemicals in body scrubs (8). The addition of chitosan from mangrove snail shells to body scrubs can improve emulsion power, viscosity, and skin moisture, and extend product durability. Therefore, chitosan is a safe and effective active ingredient to improve the quality of body scrubs while reducing the risk of irritation due to synthetic chemicals.

The purpose of this study was to evaluate the effect of chitosan with different concentrations on the quality and length of storage of body scruband determine the best chitosan concentration. This research is also expected to provide information about the best concentration of

mangrove snail shell chitosan in making body scrubs and provide added value to mangrove snail shells, as well as develop a natural body scrubbusiness.

Methodology

Material

The materials used in this study were mangrove snail shells obtained from Selat Panjang, Meranti Islands, Riau Province. The chemicals used for chitosan extraction were NaOH (Merck), HCl (Merck), and distilled water; the ingredients for making body scrubs were acetic acid, stearic acid, cetyl alcohol, Span 80, Tween 80, propylene glycol, glycerin, distilled water, white rice, and perfume; and the ingredients for microbiological analysis were 70% alcohol and nutrient agar(NA) (HIMEDIA).

The tools used in this study are tools for chitosan extraction, namely a hot platestirrer, magnetic stirrer, measuring cup (IWAKI), analytical balance (BOECO, Germany), pH meter, FTIR spectrophotometer, and oven (MEMMERT); tools for making a body scrub, namely analytical balance (BOECO, Germany), mortar, beaker (IWAKI), and mixer (PHILIPS); and microbiological analysis namely Erlenmeyer (IWAKI), Hot plate, measuring cup (IWAKI), oven (MEMMERT), autoclave model HVE-50, Japan, Incubator (BINDER), stirring rod, spatula, dropper pipette, test tube (IWAKI), and other glassware.

Research Procedures

Sampling

A total of 10 kg of mangrove snails were collected from the mangrove forests of Ransang Waters, Selat Panjang, Kepulauan Meranti, Riau Province. The sample size was determined based on field availability and transport capacity to the laboratory. Only the shells were used in this study, thus requiring a larger number of snails to obtain sufficient raw material. The snails had a maximum length of 9.80 cm, a diameter of 3.7 cm, and a maximum weight of 5.78 g per individual. Samples were transported in Styrofoam boxes to the Fisheries Product Chemistry Laboratory in Pekanbaru. Upon arrival, the flesh was separated from the shells, which were then thoroughly washed and oven-dried at 60 °C for 6 h.

Chitosan Extraction

The preparation of chitosan starts from the demineralization process, 1N HCl immersion with the ratio of sample to HCl solution = 1:7 (g/mL HCl) while heating at 90 °C for 60 min. Then decanted and washed with distilled water until the pH was neutral, then dried the precipitate. Followed by the deproteination process, soaking with 3.5% NaOH solution, with a ratio of NaOH = 1:10 (g/mL HCl) and soaked for 3.5 h and then heated at 90 °C. After that, it was cooled, decanted, and washed with distilled water until the pH was neutral, then filtered to take the precipitate. And ended with the deacetylation process, using 50% NaOH solution in a ratio of 1:10 and soaked for 1 day then heated at 140 °C for 1 h while stirring. Wash with distilled water until the pH is neutral, dried the precipitate. The result obtained is called chitosan (9).

After chitosan is obtained, chitosan powder is then made into chitosan solution. Chitosan powder was weighed 1 gram, 2 grams, and 3 grams respectively. Then, each chitosan powder was dissolved with 1% acetic acid at a ratio of 1:10 (b/v). Then, distilled water was added up to 100 mL and homogenized for 60 min. Chitosan 1, 2, and 3% were obtained (10).

Figure 1. Mangrove snails from Selat Panjang waters, Meranti Islands, Riau Province, Indonesia.

Body Scrubs Preparation

Five types of body scrubs were used in this study, one of which was made from ingredients such as stearic acid, cetyl alcohol, span 80, propylene glycol, tween 80, distilled water, glycerin, parabens and TEA. The other three types of body scrubs were made using the same basic ingredients, except that parabens and TEA were replaced with chitosan (1, 2, and 3%). One type of commercial body scrubwas also used as a comparison to the treatment with unknown ingredients. The preparation of body scrub starts with the preparation of oil base and water base materials. The oil base and water base ingredients were heated using a water bath at 65 °C for 15 min. After that, formulations for BS-1%, BS-2%, BS-3%, and BS-PT treatments were made by adding ingredients and adding 1 mL of chitosan solution. Then, the water base ingredients were poured little by little into the oil base ingredients and stirred manually using a stirring rod for 30 min until a thickened cream preparation was formed. White rice was added to the mixture, stirred again for 5 min, and perfume was added. The body scrubpreparation was then packaged in plastic pots. After formulation, the body scrub was applied, resealed, and stored at room temperature for 0, 10, 20, and 30 days for further analysis. (11).

Result and Discussion

Mangrove Snail Morphology

Morphologically, mangrove cos obtained from Selat Panjang Waters, Meranti Islands, Riau Province have conical shells, 5-10 cm long, and 3-5 cm in diameter. The shell has brown circular stripes at the base and whitish at the tip; and weighs around 4-5 g (see **Figure 1**).

Characteristics of Chitosan

Characterization of chitosan included yield value, particle shape, moisture content, ash content, nitrogen content, and degree of deacetylation of mangrove snail shell.

Yield

The yield of chitosan produced was 9.91% of the total weight of the mangrove snail shell (see **Table 1**). The yield of chitosan obtained in this study is almost the same as the reported yield of mangrove snail shell chitosan, which is

Table 1. Characteristics of chitosan from mangrove snail shell.

Parameters	Research results	EFSA 2010 (12)	SNI 7949:2013 (13)
Yield	9.91%	-	-
Particle shape	Powder	-	Flakes or powder
Water content	6.10%	≤ 10%	≤ 12%
Ash content	6.34%	≤ 3%	≤ 5%
Nitrogen content	6.57%	≤ 6%	≤ 5%
Degree of deacetylation	67.00%	≥ 90%	≥ 70%

9.90%; and greater than the yield of snail shell chitosan, which is 6.95% (14, 15). Chitosan yield is usually influenced by the concentration of solvent (NaOH) added, heating temperature, and heating duration. Heating temperature in the deacetylation process that is too high will degrade the polymer into polymers that have low molecular weight (16). Temperature can also accelerate the deacetylation reaction but if the temperature is too high, it can cause excessive release of acetylated chains in chitin so that fine chitosan particles are formed, which are then dissolved and cause a decrease in chitosan mass. Similar findings were also reported for chitosan from the shells of measles (*Atrina pectinata*) and shrimp shells (17, 18).

Water Content

Moisture content is an important product quality standard because moisture content is a factor that determines the deterioration of product quality and shelf life. The moisture content of mangrove snail shell chitosan in this study was 6.10%, which is higher than snail shell at 2.20% and lower than shrimp shell at 9.28% (19, 20). Nevertheless, the moisture content of the chitosan obtained has met the chitosan quality standard set by SNI 7949:2013, which is a maximum of 12%. The moisture content contained in chitosan is influenced by the drying method, drying time, and grain size of the dried chitosan. Chitosan that has a smaller grain size dries faster when dried, and its moisture content is usually lower than chitosan that has coarser grains. Low moisture content can suppress or reduce damage to chitosan, especially due to fungal activity (21).

Ash Content

Ash content is a mixture of inorganic or mineral components found in food. The demineralization process is a treatment stage to remove minerals, especially calcium carbonate which affects solubility, thus reducing the viscosity of the product, or can also affect other physiochemical characteristics. The ash content of mangrove snail shell chitosan from this study was 6.34%. The ash content of chitosan in this study is slightly higher than the chitosan ash standard set by SNI 7949:2013, which is a maximum of 5%. The high ash content indicates that the demineralization process was not complete, which may be caused by several factors, such as the heating temperature during demineralization which was not optimal, the relatively low concentration of HCl and NaOH in the deacetylation process, and the higher mineral content of the mangrove snail shell. In mangrove crab shells, the higher the demineralization temperature, the lower the ash content of chitosan (22). This is because the temperature can make the minerals contained in the material dissolve in the solvent. The length of deacetylation time also affects the ash content of chitosan, where the longer the deacetylation time, the lower the ash content of chitosan obtained, because more minerals in chitosan dissolve in NaOH solution).

Nitrogen Content

Nitrogen content is a parameter to determine the success of the deproteination process. In this study, the nitrogen content obtained was 6.57%, this value is slightly higher than that of rice snail chitosan, which is 6.19% (23) and lower than that of shrimp chitosan, which is 6.90% and 8.26% (24, 25). The nitrogen content of the results of this study is also higher than the SNI standard, which is <5%. The high nitrogen content in the chitosan from this study is thought to be caused by the incomplete deproteination process which causes the amino acid chain to be incompletely broken down so that protein denaturation does not take place properly. The high nitrogen content of chitosan is related to the soaking time and the method used in the deproteination process (26). In this study, the high nitrogen content was due to the poor and uneven stirring process in the deproteination and deacetylation process so the protein in the mangrove snail shell was not released much, this statement is supported by research conducted on tiger shrimp (27) and on a name shrimp (24).

Degree of Deacetylation

The degree of deacetylation is a parameter to indicate the purity level of chitosan. The extracted chitin and chitosan were identified using an infrared spectroscopic analysis technique which aims to determine their characteristic functional groups (NH, OH, C-C, CH, and C=O) (28). In this study, the chitin deacetylation reaction was carried out using a 60% NaOH strong base solution, and the degree of chitosan deacetylation obtained was 67%. This value is higher than the results of research on mangrove snail chitosan, which is 64% (14). The degree of deacetylation is also slightly lower than the standard set by the Indonesian National Standard (SNI), which is >70%. The demineralization, deproteination, and deacetylation processes carried out on chitin in this study have not optimally removed the acetyl groups, which may be due to temperature instability, insufficient reaction time, and also the stirring process (29).

Body Scrub Quality

Homogeneity

Homogeneity observation of body scrubpreparations after the addition of chitosan with different concentrations showed different levels of homogeneity. The body scrub that has the highest homogeneity is the commercial body scrub(BS-K), followed by B-2, B-3, B-1, and BS-PT (see **Table 2**). Body scrub with the addition of 2% chitosan (K-2) shows the highest level of homogeneity because the distribution of scrub particles contained in the body scrubpreparation is spread evenly to provide maximum results, this is indicated by the preparation of scrubs that have a homogeneous composition with a thick texture (see **Figure 2**). The body scrubthat uses parabens and TEA shows the lowest level of homogeneity, which is characterized by a more liquid texture with less homogeneous scrub particles. The homogeneity test is one of the physical tests of body scrub preparation

Table 2. Homogeneity test results of body scrub formulations.

Treatment	Storage Duration			
	Day 0	**Day 10**	**Day 20**	**Day 30**
BS-1%	Not Homogeneous	Not Homogeneous	Not Homogeneous	Not Homogeneous
BS-2%	Homogeneous	Homogeneous	Homogeneous	Homogeneous
BS-3%	Homogeneous	Homogeneous	Homogeneous	Homogeneous
BS-PT	Not Homogeneous	Not Homogeneous	Not Homogeneous	Not Homogeneous
BS-K	Homogeneous	Homogeneous	Homogeneous	Homogeneous

Table 3. Physical quality and microbial cleanliness of body scrubs with chitosan addition after 30 days of storage.

Parameters	Treatment				
	BS-1%	**BS-2%**	**BS-3%**	**BS-PT**	**BS-K**
Humectants	91.92 ± 1.17^{b}	94.75 ± 0.42^{c}	95.58 ± 0.32^{c}	89.83 ± 1.23^{a}	98.17 ± 0.33^{d}
Viscosity	2352.28 ± 124.93^{a}	3746.05 ± 279.98^{b}	3407.33 ± 398.15^{b}	2142.78 ± 64.41^{a}	4745.93 ± 552.20^{c}
Stickiness	5.74 ± 0.20^{b}	6.12 ± 0.08^{b}	5.77 ± 0.24^{b}	5.13 ± 0.04^{a}	7.89 ± 0.10^{c}
Spreadability	5.39 ± 0.39^{a}	6.52 ± 0.19^{c}	5.96 ± 0.48^{b}	5.70 ± 0.18^{ab}	8.22 ± 0.12^{d}
pH	6.42 ± 0.05^{bc}	6.38 ± 0.03^{b}	6.17 ± 0.10^{a}	6.44 ± 0.06^{c}	6.48 ± 0.01^{c}
Total bacteria	7.13×10^{2b}	6.45×10^{2b}	5.51×10^{2b}	6.68×10^{2b}	2.30×10^{2a}
Total mushrooms	3.21×10^{2b}	2.84×10^{2b}	2.58×10^{2b}	2.54×10^{2b}	9.90×10^{1a}

Note: Values with the same superscript letter are not significantly different. Differences were considered significant at $p < 0.05$.

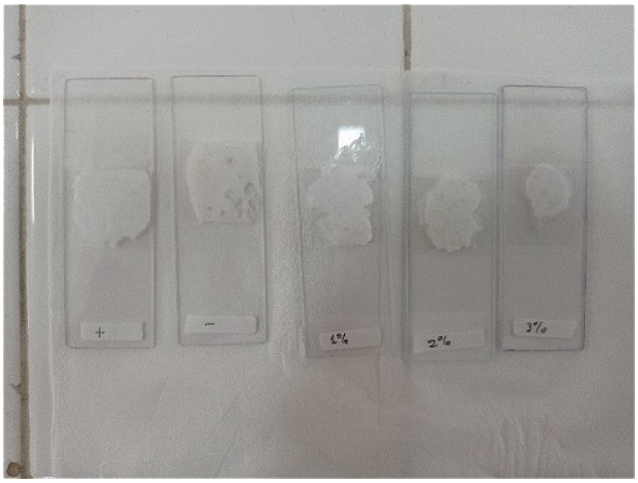

Figure 2. Homogeneity test of body scrub formulations.

products in moisturizing the skin. The better the level of homogeneity of skin moisturization, the more active substances in the body scrubwill spread evenly on the skin (30).

Table 3 presents the results of quality evaluations for five types of body scrubs formulated with different ingredients, including chitosan derived from mangrove snail shells, after 30 days of storage. The assessment aimed to determine the stability of texture, moisture retention, pH level, and microbial cleanliness of each formulation, as detailed below.

Humectants

The stability of the humectant value of chitosan body scrub during storage showed that BS-2% and BS-3% formulations were more stable (94.75 and 95.58) than BS-PT (89.83) and BS-1% (91.92), although still lower than the commercial product (98.17). These high humectant values indicate the ability of chitosan from mangrove snail shells to retain skin moisture, exceeding previous studies that only reached 55.99-66.6% in face cream and hand body cream products (31, 32). This ability comes from the nature of chitosan, which has hydrophilic (binds water from the environment) and hydrophobic (retains water in the skin) groups, as well as hygroscopic properties that can attract water molecules (33). While not yet matching commercial products, the BS-2% and BS-3% formulations offered significant improvements in moisture stability over previous studies.

Viscosity

The addition of 2% chitosan (BS-2%) to the body scrubproduced the highest viscosity value of 3746.05 cPs, which was significantly higher than BS-1% and BS-PT. Although the viscosity value of this chitosan body scrub is still lower than commercial body scrubs, it still meets the ideal viscosity standard according to SNI 16-4399-1996 (2000-50,000 cPs). During storage up to 30 days, the viscosity of 2% and 3% chitosan body scrubremained relatively high (3476.03 and 2923.55 cPs) compared to BS-PT (2056.20 cPs), despite the gradual decrease in viscosity value. This indicates that the addition of chitosan can improve the viscosity and stability of body scrubviscosity, which is important for product quality and convenience. Thus, chitosan functions effectively as a natural thickening agent that meets the quality standards of body scrubproducts.

Stickiness

The adhesion values of chitosan body scrubs during storage

ranged from 5.13 to 6.12 s, with BS-2% showing the highest average value and BS-PT the lowest, but all still met the minimum standard of 4 s (34). During 30 days of storage, BS-2% maintained the best adhesion stability with minimal decrease, while BS-PT experienced the most significant decrease. Stickiness is closely related to viscosity, body scrubs with higher viscosity tend to have greater stickiness due to their thicker and more elastic texture, making it easier to adhere to the skin but less easy to spread (35). Conversely, low adhesion indicates a more watery texture and easy spreading, albeit less adherent. Thus, the addition of chitosan increased the adhesiveness of the body scrub significantly, providing a balance between viscosity and adhesiveness that is important for product comfort and effectiveness.

Spreadability

The study showed that body scrubwith 2% chitosan added (BS-2%) had the highest mean spreadability value of 6.52 cm, while BS-1% had the lowest value of 5.39 cm, and all formulations met the spreadability standard of topical preparations between 5 to 7 cm. Analysis of variance confirmed that the addition of chitosan had a significant effect on spreadability, with BS-2% significantly different from the other treatments. The higher the concentration of chitosan, the spreadability ofbody scrubs tends to increase, which is closely related to viscosity; lower viscosity allows the cream to flow and spread more easily on the skin, while high viscosity decreases spreadability (36). The addition of ingredients such as stearic acid that increase viscosity will decrease spreadability, so a balance is needed so that the product is easily absorbed without irritating. Thus, proper formulation of body scrubwith chitosan can improve the spreadability of the product on the skin, supporting optimal absorption and comfortable use according to applicable standards.

pH

The study showed that the addition of chitosan significantly affected the pH value of the body scrub, with BS-PT having the highest pH value (6.44) and BS-3% the lowest (6.17). During the 30-day storage, the pH value of the body scrubdecreased gradually, with BS-2% and BS-3% showing the best stability. Although the pH stability of chitosan body scrubs is lower than that of commercial products, all formulations still meet the SNI 16-4399-1996 standard (pH 4.5-8), making them safe to use without the risk of irritation or dry skin. This shows that chitosan is effective as an active ingredient that affects the pH characteristics of body scrubs. This decrease in pH is caused by environmental factors, such as poorly sealed storage containers that allow the interaction of carbon dioxide with the aqueous phase, as well as the activity of microorganisms that affect the composition of active ingredients (37). Higher concentrations of chitosan tend to lower the pH because the H+ ions in chitosan increase the acidity of the product (38).

Total Bacteria

The addition of chitosan to the body scrubhad a significant effect in inhibiting bacterial growth, with 3% concentration (BS-3%) showing the lowest bacterial growth value (5.51×10^2) compared to 1% concentration (BS-1%) which had the highest value (7.13×10^2). Analysis of variance confirmed the significant effect of chitosan on microorganism growth, although BS-1% was not significantly different from BS-PT, BS-2%, and BS-3%, it was different from the paraben preservative treatment (BS-K) which showed the lowest and stable microorganism growth during 30 days storage. Chitosan effectively inhibits bacteria thanks to its positively charged amino groups that bind to the negatively charged microbial wall, causing cell structure damage and microbial death. The antimicrobial effectiveness of chitosan is influenced by concentration, molecular weight, and degree of deacetylation, and is supported by phenolic compounds and acetic acid solvents that also have antimicrobial properties (39). Although the effectiveness of chitosan is not yet optimal due to its purity, the results of this study indicate that chitosan can be an effective alternative natural preservative in cosmetic products such as body scrubs, providing additional protection against microbial contamination without exceeding the safe limit of microbial contamination according to BPOM.

Chitosan works as an antibacterial by binding and damaging the microbial cell wall, disrupting metabolism, and causing cell lysis, thereby inhibiting bacterial growth on the product (40, 41). This makes chitosan a potential active ingredient to enhance the safety and longevity of cosmetic products naturally while reducing dependence on synthetic chemical preservatives such as parabens.

Total Fungi

The addition of chitosan to the body scrubhad a significant effect on total mold growth, with 1% concentration (BS-1%) showing the highest total mold value (3.21×10^2) and paraben preservative treatment (BS-K) having the lowest value (9.90×10^1). Chitosan acts as a natural antimicrobial agent capable of suppressing mold growth in cosmetic products by damaging the structure of the microbial cell wall and disrupting its metabolism. Chitosan effectively inhibits fungi through the mechanism of binding cationic amino groups with the negatively charged fungal cell wall, causing membrane depolarisation and microbial death (42). An increase in the number of molds during storage may result from cross-contamination from the environment, production process, and usage factors such as frequency of use and storage conditions (43). However, its effectiveness is affected by external factors such as less-than-optimal production and storage sanitation, so strict quality control is needed to minimize microbial contamination. All samples still met the BPOM standards regarding microbial contamination ($<10^3$ colonies/g), so the products remain safe to use. Thus, chitosan can be an effective alternative natural preservative in maintaining the safety and quality of body scrubs during their shelf life.

Conclusion

Based on the results of the study, the characteristics of mangrove snail shell chitosan were obtained, namely the yield value of 9.907%, in powder form, with a moisture content value of 6.10%, ash content of 6.34%, nitrogen content of 6.57%, and deacetylation degree of 67%. The addition of different concentrations of chitosan has a significant effect on the characteristics of body scrubs ranging from homogeneity, humectant, viscosity, adhesiveness, spreadability, pH, total bacteria, and total fungi. The best treatment is the addition of 2% chitosan in terms of product homogeneity, humectant (94.75%), viscosity (3746.05 cps), adhesiveness (6.12 s), spreadability (6.52 cm), pH (6.38), total bacteria and total fungi (10^3).

Chitosan has antimicrobial properties, helping to extend the shelf life in maintain the safety and quality of body scrubs.

However, this study has several limitations. The ash and nitrogen contents of the extracted chitosan exceeded the maximum thresholds set by the Indonesian National Standard (SNI), indicating that the demineralization and deproteinization processes were not yet optimal. This may affect the purity and functional effectiveness of chitosan as an active ingredient in cosmetic formulations.

Future research is recommended to optimize the chitosan purification process, particularly during the demineralization and deproteinization stages, in order to produce higher-quality chitosan that meets both national and international quality standards. Additionally, long-term product stability testing and specific antimicrobial efficacy evaluations against selected bacterial or fungal strains should be conducted to strengthen the evidence of chitosan's benefits in natural cosmetic formulations. Improved purification is expected to enhance the antimicrobial activity of chitosan and broaden its potential for commercial application in the cosmetic industry.

Abbreviations

SNI = Indonesian National Standard, BPOM = Directorate General Drug and Food Control

Declarations

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Conflict of Interest

The authors declare no conflicting interest.

Data Availability

The unpublished data is available upon request to the corresponding author.

Ethics Statement

Not applicable.

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