Utilization of Shrimp Shell Waste as a New Material for Chitosan

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Abstract. Allah gave this universe for human needs in living life in the world. Allah gave the mandate to humans to protect nature and the environment to create harmonization in life. However, many humans violate Allah's commands by destroying and polluting the environment. Waste generated continues to increase and this harms the environment. Shrimp is an important commodity in the seafood business. This business produces waste in the form of shrimp shells which causes pollution in the form of a foul odor and disrupts environmental sustainability. This research turns shrimp waste into new product chitosan which is useful and has economic value. This research is an experimental study conducted in a laboratory with the processes of deproteinization (NaOH 3.5%), demineralization (HCl 1M), and deacetylation (NaOH 60%). The results obtained showed good quality chitosan with white color, odorless, and the degree of deacetylation was 73.74%.

Keywords: Utilization · Shell Waste · Chitosan

1 Introduction

Islam is a religion that spreads goodness and benefits for the good of the universe [1, 2], not a radical religion that spreads evil to destroy the universe [3, 4]. Allah has given us extraordinary natural resources on this earth. A variety of flora and fauna complement human life. In the Qur'an, several plant names are used for surah names such as At-Tin which means fig [5], as well as animal names such as ants, bees, elephants, and spiders. All plants and animals have a role in the human life cycle. Animals are used for food, transportation, and economic commodities [6]. Natural resources in the form of marine products such as shellfish, fish, and shrimp are good economic commodities [7]. Every day the number of shrimp continues to increase for food needs. This causes food waste and shrimp shells to continue to grow. This has a negative effect on environmental pollution such as garbage, odors, and becomes a source of disease [8, 9]. Many methods are used in processing waste such as the 3R method (reuse, reduce, recycle) [10–13]. Shrimp waste can be processed using the recycling method, converting shrimp shells into chitosan which is useful and has economic value [14, 15]. Shell waste has chitin

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which can be processed into chitosan [16–18], so it can be used and has economic value. Chitosan is a chitin derivative compound that has an active amine substance that is non-toxic and can be implemented in various ways [19, 20]. Chitosan can be obtained by removing acetyl in chitin through the deacetylation process [21–27]. The loss of acetyl will be proportional to the quality of the chitosan obtained [24, 28]. Chitosan can be used as an ingredient for cosmetics [29, 30], biosensors [31, 32], pharmaceuticals [14, 18], waste treatment [33–35], and health [36, 37]. In the cosmetic field, chitosan is used as a moisturizer and sunscreen in beauty products [38]. In the field of biosensors, chitosan is used as an active compound in sensors [31, 32]. In waste treatment, chitosan is used as an absorbent for heavy metals and color pollution. In health, chitosan is used for wound medicine, immunology, and anti-coagulant [37, 39]. The implementation of chitosan in various fields causes market demand to increase so that it becomes a good export commodity to be sold to international markets [40, 41].

Chitosan production provides a great opportunity for business. Raw material from shrimp shell waste will facilitate the production process at a low cost. Chitosan has more benefits than chitin. Therefore, it is very important to process shrimp shell waste into a new product of chitosan that is useful, has economic value, and reduces environmental pollution [42].

2 Methods

The tools used in this study were beaker glass, hotplate, sieve, desiccator, magnetic stirrer, oven, and FTIR. The materials used in this study were distilled water, shrimp shells, 3.5% NaOH, 60% NaOH, and 1 M HCl.

2.1 Making Shrimp Shell Flour

The shrimp shell waste was washed with water until clean and then put in the oven at 110 °C for 1 hour. Shrimp shells put in a desiccator. The shrimp shell obtained was crushed and sieved with a size of 100 mesh.

2.1.1 Deproteination Process

Shrimp shell powder was added to 3.5% NaOH solution with a ratio of 1:10 (w/v) between the solvent and the sample. The mixture was put into a beaker glass and then heated at 60 °C for 4 hours. Stir during the heating process at a speed of 50 rpm. The shrimp shell powder was washed with distilled water until the pH was neutral, put in the oven at 80 °C for 24 hours, and cooled in a desiccator.

2.1.2 Demineralization Process

As much as 200 g of shrimp shell powder was added to 1 M HCl solution with a ratio of 1:15 (w/v), heated at 60–70 °C for 4 hours, and washed with distilled water until the pH was neutral. Shrimp shell powder was put into the oven at 80 °C for 24 hours, and cooled in a desiccator. Shrimp shell powder was tested with FTIR to determine the chitin content in the shrimp shell.

2.1.3 Deacetylation Process

Shrimp shell powder containing chitin was added to 60% NaOH with a ratio of 1:20 (w/v). The mixture was stirred and heated at 110 °C in an oil bath for 4 hours. The results obtained were washed with distilled water until the pH was neutral, and put in the oven at 80 °C for 24 hours. Shrimp shell powder is cooled in a desiccator. Shrimp powder was analyzed by FTIR.

3 Result and Discussion

Several processes of processing shrimp shell waste into chitosan are deproteinization, demineralization, and deacetylation. Deproteinization is the process of removing the protein present in shrimp shells using 3.5% NaOH. The protein in the shrimp shell will be bound by Na+ ions from NaOH, this causes the mixture to become thick and bubbles. The deproteinization reaction process can be accelerated by heating at 60 °C for 4 hours. It is expected that the release of protein in the shrimp shell will be maximized without damaging the active compounds in the shrimp shell [42]. The second process is demineralization, which aims to separate the minerals in the shrimp shell with the addition of 1M HCl. Mineral content such as calcium carbonate ($CaCO_3$) in shrimp shells will be bound by Clions from HCl. The demineralization process causes the mixture to release bubbles of CO_2 gas. The chemical reactions that occur in the demineralization process are as follows: $CaCO_3 + 2\ HCl \rightarrow CaCl_2 + H_2O + CO_2$ Shrimp shell powder that has passed the deproteinization and demineralization process will be analyzed by FTIR. This aims to determine the functional groups of chitin in shrimp shell powder. The third process is deacetylation, which is the process of changing the acetyl group (-COCH3) in chitin to become an amine group (-NH2) [43]. The chemical reaction for deacetylation process as shown in Fig. 1.

The deacetylation process in an alkaline environment can increase the amount of amine group formation. The high concentration of NaOH can donate a large number of -OH groups so that the -COCH3 group that reacts is also increasing. Therefore, more and more amine groups are formed and the degree of diacetyl is higher. The amine group causes chitosan to have better potency and benefits than chitin. The resulting chitosan has physical properties such as crystalline, odorless, and white as shown in Fig. 2.

The functional groups in chitin and chitosan were analyzed by FTIR [44, 45]. This aims to determine the changes and differences in functional groups between chitin and chitosan. The change of the acetyl functional group into an amine is an indicator of the success of the chitosan synthesis process [46]. The results of the FTIR analysis can be seen in Fig. 3.

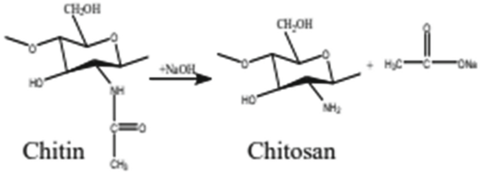

Fig. 1. The chemical reaction for deacetylation process

Fig. 2. Chitosan from shrimp shells

The results of the FTIR analysis showed that there was a change in several functional groups in chitin. After the deacetylation process, the C=O group at a wavelength of 1680–1660 cm-1 was lost. This indicates that acetyl is lost in the synthesized chitosan. There is a vibration of the NH2 group which indicates that the acetyl group is released and an amine group (NH2) is formed [18, 46].

The amount of acetyl lost and the number of amine groups formed is indicators of the quality of chitosan which is called the degree of deacetylation [47, 48]. The chitosan produced in this study had a degree of deacetylation of 73.7%.

The chitosan produced has good quality standards because it is following international standards as shown in the Table 1 [49]. Based on the quality obtained, the chitosan from shrimp shell waste is suitable for use in various fields. This can provide business opportunities for society. Chitosan is widely used as an absorbent to overcome heavy metal pollution, preservatives, antibacterial, anti-cancer, cosmetics, flocculants,

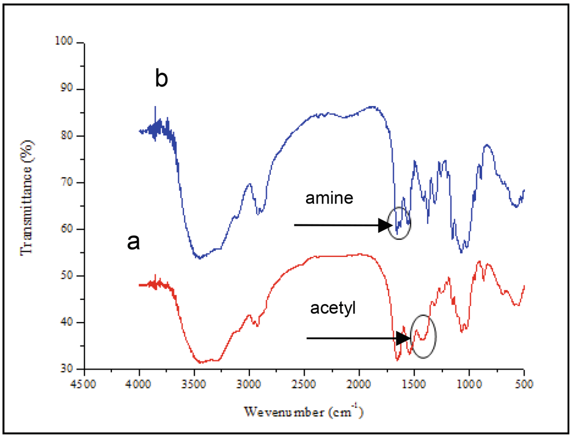

Fig. 3. FTIR results of chitin (a) and chitosan (b)

Tabel 1 Kitosan Characteristic

No	Parameter	Chitosan International Standard	Chitosan Produced
1	Shape	Crystal	Crystal
2	Smell	No smell	No smell
3	color	White	white
4	Degree of deacetylation	≥70%	73.7%

and pharmaceuticals. The many benefits of chitosan make market demand increase. This is a business opportunity to improve the economy and people prosperous [50].

Repairing the damaged environment and keeping the environment healthy and clean is our collective duty. Converting shrimp shell waste that smells and pollutes the environment into new products of chitosan is a good thing to treat waste and protect the environment.

4 Conclusion

Shrimp shell waste can be processed into chitosan so that it is more useful and has economic value. Processing of shrimp shell waste through deproteinization, demineralization, and deacetylation processes. The chitosan produced has good quality according to international standards. The chitosan characters obtained were crystalline, white in color, odorless, and had a degree of deacetylation of 73.7%.

Author's Contribution

This research is a combination of ideas from several authors from various disciplines. The combination of science, chemistry, Islam, economics, and social sciences makes this research even more interesting and comprehensive.

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