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The Effect of NaOH Concentration on The Physical and Chemical Properties of Jerbung Shrimp (*Fenneropenaeus Merguiensis de Man*) Waste Powder

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Abstract :
This research was conducted to determine the effect of NaOH concentration on the physical and chemical properties of shrimp waste powder. This research used a Completely Randomized Design (CRD) with NaOH concentration treatment consisting of 5 levels (1%, 1.25%, 1.5%, 1.75% and 2%) and 4 repitition. The data obtained were analyzed statistically using analysis of variance and followed by Duncan's New Multiple Range Test (DnMRT) when necessary. The research shows that the NaOH concentration has a significant effect on the ash content, protein content, L* and b* values, but has no significant effect on the water content, fat content, solubility and a* values. The best characteristics of shrimp waste powder is obtained using NaOH 1.5% which produces powder with 4.22% water, 39.27% ash, 18.37% protein, 12.43% fat, solubility of 4. 04%, L* value 48.37, a* value 10.92 and b* value 21.47.

Keywords : Jerbung, Powder, Shrimp Waste

1. Introduction

The contribution of Indonesia's fisheries sector to the economic development of the people and the country is considered very small. The vast sea area is the reason why the fisheries and marine sector is one of Indonesia's foreign exchange earners. Shrimp is one of the fishery commodities that is in great demand by the public because it has a good taste, attractive aroma, and high nutritional value. Generally, shrimp exported by Indonesia is divided into two types, namely fresh shrimp and frozen shrimp (Ashari et al., 2016). For export, shrimp are processed to produce peeled shrimp, leaving waste in the form of skin, legs, tails and shrimp heads that are quite high. Shrimp waste can be a pollutant to the environment because waste is included in the category of the requirements of a substance called a pollutant. A substance can be called a pollutant, if the amount exceeds the normal amount, is at the wrong time, and is in the wrong place (Hakim et al., 2017).

Shrimp waste comes from the head, skin and tail of the shrimp. These parts contain chemical compounds namely protein, fat, calcium carbonate, ash, and chitin. Shrimp waste that has not been optimally utilized causes the waste to have less economic value compared to processing it into chitin for chitosan raw materials with high economic value (Suherman et al., 2018). And the acquisition of chitin from shrimp waste requires several processes, namely deproteination (protein separation) and demineralization (mineral separation). Chitin is a polysaccharide consisting of N-acetyl-D-glucosamine connected by β-1,4-glycosidic bonds. Shrimp waste is one of the important sources of chitin. Chitin is considered the second most abundant polymer after cellulose. Shrimp waste has benefits, including those contained in shrimp waste, namely protein (53.74%), chitin (14.61%), fat (6.65%), water (17.28%) and ash (7.72%) (Pratiwi et al., 2020).

Shrimp waste contains chitin which can be processed into chitosan, a raw material for bioplastics. However, the processing of shrimp waste into chitosan involves demineralization, deproteinization and deasetilation which leave chemical residues. This may leads to an environmental pollution. To solve the problem, the processing of shrimp waste can be simplified by saving some mineral and protein that are useful in bioplastic production and at the same time reduce the amount of chemical needed for the process. It is expected that shrimp waste can be processed into powder which contains enough amount of mineral and protein as well as chitin/chitosan which beneficial for bioplastics production. For this purpose, the complex mineral-chitin-protein in shrimp waste should be broken down using an alkaline solution such as NaOH.

This study aims to determine the effect of NaOH concentration on the physical and chemical properties of jerbung shrimp skin powder, and to determine the NaOH concentration that produces the best physical and chemical properties of jerbung shrimp skin powder used as bioplastic material.

2. Research Method

Materials and Tools

The materials used in this study were shrimp skin, head, tail and legs, NaOH, CH_3COOH, $CuSO_4$, Na_2C0_3, distilled water, and n-hexane. The tools used in this research were color readers.

Research Design and Statistical Analysis

This experiment used a completely randomized design (CRD) with the treatment NaOH concentration consisting of 5 levels, namely 1%, 1.25%, 1.5%, 1.75%, and 2%. Each treatment was repeated 4 times to obtain 20 experimental units.

Preparation of Shrimp Waste Powder (Puspitasari & Ekawandani, 2019 and Astuti 2023 modified)

Jerbung Shrimp was in good condition, has a hard texture and is still fresh and does not smell bad. The waste including skin, tails, legs and shrimp heads. The waste were washed using running water to wash away impurities and contamination. Cleaned shrimp waste were then homogenized and dried using an oven at 110-120°C for 5 hours. Next, the size reduction process is carried out using a blender and sifted using a 60 mesh sieve.

Furthermore, the shrimp waste powder was weighed as much as 80gr and soaked using a 10% acetic acid solution for 1 hour, at this stage the minerals contained in the shrimp waste reacted with acetic acid resulting in the separation of minerals from shrimp waste. Then filtered and washed using distilled water until the pH is neutral and then dried in an oven at 105°C for 3 hours.

Next, the material was placed in a glass beaker, was added NaOH solution, (1%, 1.25%, 1.5%, 1.75%, and 2%,) with the ratio for soaking shrimp waste was 1: 5. The material was stirred at 65°C for 2 hours using a hot plate stirrer, cooled down, and then filtered. The residue were washed with distilled water until the pH is neutral and dried in an oven at 110-120°C for 4 hours until the shrimp waste is completely dry. After the drying process was complete, then the size reduction process was carried out using a blender and then sieved using a 60 mesh sieve.

Parameter

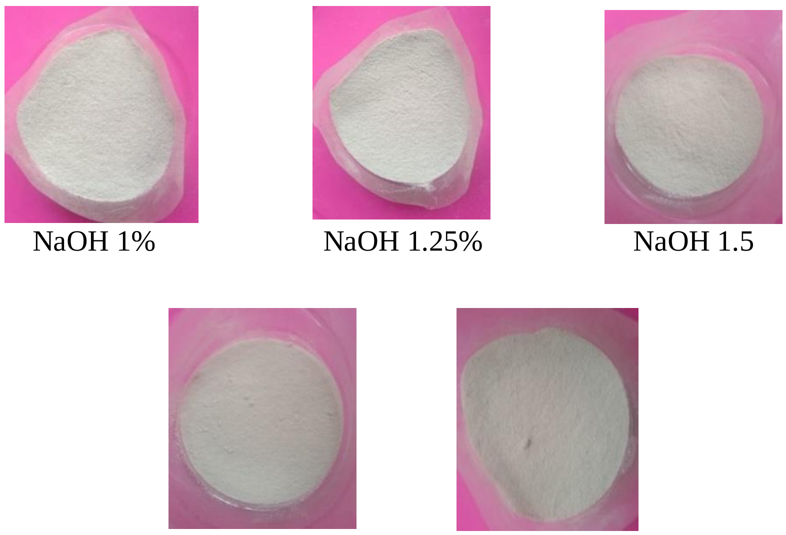
The parameters observed were moisture content analysis (AOAC, 2005) ash content analysis (AOAC, 2005), protein content analysis (AOAC, 2005), fat content analysis (AOAC, 2005), solubility analysis (Agustina et al., 2015), hunter method color analysis (Andarwulan et al., 2011).

Data Analysis

The data obtained from this study were analyzed statistically using analysis of variance at 1% and 5% level. If data were significantly different, the analysis was continued with Duncan's New Multiple Range Test (DNMRT) at the 5% level.

3. Result and Discussion

Shrimp waste powder is a product produced from processing shrimp waste in the form of shrimp heads, tails, legs, and heads to become powder. Shrimp waste powder obtained in this study is in the form of fine powder measuring 60 mesh by crushing and sieving. The results of shrimp waste powder from various NaOH concentrations can be seen in Figure 1.



NaOH 1% NaOH 1.25% NaOH 1.5

NaOH 1.75% NaOH 2%

Figure 1. Shrimp waste powder treated with several levels of NaOH concentration

Composition of Shrimp Waste Powder

NaOH concentration has no significant effect on the moisture and fat content of shrimp waste powder (Table 1). The moisture content of shrimp waste powder ranged from 4.24 to 5.85. This low water content can minimize the media for microbial growth (Suryo, 2019). The lower the moisture content, the better the quality of the product (Maltadevi 2022). According to Leviana and Paramita (2017) water activity which closely related to the water content in the material, affects the shelf life of the product. The smaller the water activity, the longer the shelf life is.

Table 1. The chemical composition of shrimp waste powder

[NaOH] (%)	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Solubility (%)
1	4.24±0.49	28.68±2.23^{a}	22.79±2.55^{c}	1.79±0.77	3.82±1.01
1.25	4.70±1.01	33.34±4.54^{ab}	21.0 ±0.69^{bc}	1.36±0.47	3.63±1.35
1.5	4.22±0.01	39.27±7.62^{b}	18.37±2.76^{ab}	2.43±0.55	4.04±0.79
1.75	5.46±0.82	38.59±2.14^{b}	16.66±1.02^{a}	2.46±0.50	5.60±1.37
2	5.85±0.63	39.00±5.07^{b}	17.06±1.51^{a}	2.28±0.38	5.31±1.07

Note: Numbers followed by different uppercase letter in the same column are significantly different at the 5% level according to the DnMRT test.

Shrimp waste powders contain fat ranged from 1.79% to 2.28% (Table 1). These results are much lower than the fat content of shrimp shells which is 11.9 ± 1.4% (Trung et al., 2012). The fat in shrimp shell might have dissolved in acetic acid during the soaking process, not in NaOH solution. The concentration of NaOH, therefore did not affect the fat content in shrimp waste powder. According to Dias et al. (2010) in Purbasari et al. (2014) fat contained in bioplastics raw materials can affect the strength of bioplastics. The higher the fat content, the weaker the bioplastic strength due to less cohesive and continuous film matrix. A low fat content in powder is preferred since they are less likely to get rancid.

NaOH concentration has significant effect on the ash content of shrimp waste powder (Table 1). Ash content is one of the calculations of the amount of mixture of inorganic or mineral components contained in a material. Ash is an inorganic substance left over from the combustion of an organic material (Mahyudin et al., 2011). The ash content and its composition depend on the type of material and the method of ignition, while minerals are the constituent components of ash contained in different proportions depending on the type of organic material (Nduru et al., 2018).

The ash content of shrimp waste powder ranged from 28.68% - 33%. Increasing concentration of NaOH increases the ash content of shrimp waste powder. NaOH dissolves mineral from the shrimp waste and washes them away (demineralization). Treatment with NaOH can also hydrolyze organic compounds such as proteins (deproteination). The amount of minerals that are slightly reduced and the total material after treatment is less can cause the mineral presentation to increase (Darmiyati et al., 2018). This is in line with the research of Trilaksani et al (2006) where the high ash content in bone meal can be caused by minerals and in the manufacturing process protein hydrolysis occurs so that low protein levels are produced.

Sufiani's opinion, (2022) the increase in calcium, which is one of the minerals, is caused by the increasing number of proteins that dissolve in the extraction process using NaOH. Sulistyawati et al., (2020) also argue that the longer the heating process and the temperature is too high, the more minerals dissolve in the NaOH solution. According to Aldes et al., (2021), which states that ash content shows metal oxides and minerals contained in a material. The high ash content of a material identifies the high content of metal oxides and minerals contained in the material. The ash formed is metal oxides or burnt metal. according to Akbar, (2022), high ash content indicates high mineral content. The higher the ash content, the lower the quality and purity level. A good washing process until a neutral pH is reached affects the ash content. Incomplete washing will result in minerals that have been released. can reattach to powder molecules, so they still contain high ash content. (Kusmiati and Nurhayati 2020). According to (Winarti et al., 2008 in Amrie, 2017), the lower the ash content produced, the higher the quality and purity of chitin.

Long-chain amino acids with many bonds are called peptide bonds. Protein is needed to form various biologically active compounds, growth, repair or maintain tissues, and can also serve as a source of energy (Subandiyono and Hastuti, 2020). Protein content is determined using the Kjeldahl method, because in general this method is used for protein analysis in food. Based on Table 1, it is known that the treatment of NaOH concentration on shrimp waste powder has a significant effect on the protein content of shrimp waste powder produced. The value of protein content in shrimp waste powder ranged from 22.79 to 17.06%. However these numbers are overestimate as the powder also contains nitrogen from chitin or chitosan.

Table 1 shows that there is a decrease in the provision of NaOH concentration in the deproteination process, namely the higher the NaOH concentration, the lower the protein content produced. Proteins contained in shrimp waste can dissolve in an alkaline atmosphere so that proteins that are covalently bound to chitin functional groups will be separated, but there are also proteins that are physically bound, namely proteins from the remnants of meat attached to the waste which vary in amount.

The use of NaOH solutions with high concentrations and temperatures is increasingly effective in removing proteins and causing the deacetylation process (Karmas, 1982 in Agustina et al., 2015). In addition, the heating and stirring process can also help accelerate the process of binding the ends of the protein chain with NaOH so that the process of protein degradation and protein precipitation can take place perfectly (Agustina et al., 2015). The decrease in protein content is because the higher the temperature, the more dissolved protein. At the time of extraction, the higher the temperature, the greater the possibility of reducing the attraction between water molecules and providing more energy to the water molecules to overcome the attraction between protein molecules. These water molecules with the polar groups of protein molecules then form hydrogen bonds so that the protein becomes soluble. The higher the temperature, the more protein dissolves (Darmiyati et al., 2018). At low temperatures, water molecules move more slowly and have more difficulty forming hydrogen bonds with the polar groups of protein molecules. As a result, proteins become more difficult to dissolve.

In Rini's research (2010), soaking in HCl and then followed by NaOH soaking also tends to reduce protein levels in shrimp skin and heads, this is possible because the initial HCl concentration used resulted in many protein molecules being hydrolyzed. The process of protein hydrolysis will increase the polarity of the protein so that molecules that are insoluble in water will become soluble during the soaking process. According to Sukardjo and Mawarni (2011), the higher the NaOH concentration and deproteination temperature, the more effective the protein separation process.

Solubility

Solubility is a test that aims to determine the amount of substance that can be dissolved in a solvent in a product. (Umah et al., 2021). The results of the analysis of variance showed that the treatment of NaOH concentration did not significantly affect the solubility value of shrimp waste powder can be seen in Table 1.

The data generated by the solubility value of shrimp waste powder ranged from 3.82% -5.31%. The lowest solubility was in the treatment of 1.25% NaOH concentration, namely 3.63% and the highest value was in the treatment of 1.75% NaOH, namely 5.60%. The low solubility of shrimp waste powder is because the powder contains chitin which cannot dissolve in water. This is supported by the statement of Mahyudin et al. (2011) that in the solubility test with chitin products it is known that chitin is insoluble in water, but partially soluble with LiCI / dimethylacetamide.

According to Prameswari et al. (2022) plastic made from cassava starch has low water resistance, but with the addition of chitin or chitosan in the manufacture of bioplastics, the tensile strength value of plastic will increase. According to Cengristitama & Wulandari (2021) if bioplastics have very low water resistance, it can cause the solubility of bioplastics in water to accelerate so that bioplastics will be easier to destroy, this can prove that bioplastics are not resistant to water. According to Situmorang et al. (2019), the expected bioplastic composite is a bioplastic composite that has the smallest water absorption strength value. The use of chitosan also affects the value of water resistance. Its hydrophobic nature makes chitosan have a high level of resistance to water. This is caused by chitosan being able to cover the surface of bioplastics from a large porous state to a small porous one. This is proven by Indriyanto (2014) in his research, namely bioplastics without the addition of chitosan has a solubility rate of 80%. That value is the highest solubility value compared to bioplastics with the addition of chitosan, which means the addition of chitosan will reduce the moisture of bioplastics. This shows that low chitosan solubility can produce better bioplastics.

Color

Color is the first indicator seen and observed by consumers. Attractive colors will increase product acceptance (Nurhadi and Hasanah, 2010 in Simatupang, 2023). The color of food is influenced by the absorption and reflection of light from the material, as well as by dimensional factors such as product color, brightness and clarity of product color. The parameters of the color tested include L*, a* and b* values. Determination of color in shrimp waste powder is done to determine the effect of NaOH concentration on the value of L* (brightness), a* (redness), and b* (yellowish) in shrimp waste powder using a color reader. Color description was determined using color hexa by entering the L*, a* and b* values accessed at https://www.colorhexa.com/. The results of color testing on shrimp waste powder with various concentrations of NaOH solution can be seen in Table 2.

Tabel 2. Average color values of shrimp waste powder

NaOH (%)	Color Parameter			Description
	L*	a*	b*	
1	47.22±0.38[b]	11.15±0.17	22.07±0.22 [b]	*Dark moderate orange*
1.25	47.65±0.35[b]	11.02±0.09	21.7±0.11[a]	*Dark moderate orange*
1.5	48.37±0.20[c]	10.92±0.15	21.47±0.09 [a]	*Dark moderate orange*
1.75	47.52±0.34[b]	11.07±0.17	22.22±0.25[bc]	*Dark moderate orange*
2	46.45±0.17[a]	11.27±0.25	22.5±0.32[c]	*Dark moderate orange*

Note : Numbers followed by uppercase letters indicate that they are significantly different at the 5% level according to the DnMRT test.

Based on the analysis of variance, it can be seen that the treatment of soaking in various concentrations of NaOH has a significant effect on the value of L* (brightness), b* (yellowish), and has no significant effect on the value of a* (redness) in shrimp waste powder. The color test value of shrimp waste powder with various NaOH concentration treatments had L* (brightness) values ranging from 47.22 - 46.45. The resulting L* (brightness) value showed an increase with the soaking treatment using NaOH.

NaOH can cause deproteination (protein removal) so that in the heating process, the maillard reaction or non-enzymatic browning between amino groups in amino acids and the results of fat oxidation that causes the occurrence of brown pigments is reduced so that the resulting shrimp waste powder is brighter (Trilaksani et al., 2012). From the test results, the a* value did not significantly affect the NaOH concentration treatment, the test results showed values ranging from 11.15-11.27. According to Dompeipen et al. (2016), the process of separating protein bonds with chitin using NaOH (deproteination) causes the solution to thicken and become reddish in color. The b* value produced had a significant effect on the NaOH concentration treatment, the test results showed values ranging from 22.07-22.5. The value shows the chromatic color of the blue-yellow mixture with values from 0 to +70 indicating blue and the value shows yellow (Souripet, 2015). Based on the color distribution according to the combination of L* (brightness), a* (redness), and b* (yellowish) values with various NaOH concentration treatments on shrimp waste powder, it can be seen that the color of shrimp waste powder produced has a dark moderate orange appearance. According to Ciapara et al., (2006) shrimp heads have a brownish red color this is because carotenoids are included in a group of pigments that are yellow, yellowish red or dark red, have properties that are very soluble in oil and are hydrocarbons that have many unsaturated bonds which cause the pigment to be easily oxidized. Beta carotene is a carotenoid pigment that has a chromophore group, a conjugated double bond. This chromophore group causes the formation of color in carotenoids, the more conjugated double bonds the more red or orange (Ayudiarti, 2011).

4. Conclusion

NaOH concentration had a significant effect on ash content, protein content, L* and b* values of shrimp waste powder, but had no significant effect on the water content, fat content, solubility and a* value. Considering the solubility of the powder, the least soluble powder may be needed for bioplastics production in order to increase its waterproof characteristics and decrease its water vapor transmission rate. This characteristics of shrimp waste powder are found in soaking with NaOH solution at a concentration of 1% which has characteristics of water content of 4.24%, ash content of 28.68%, protein content of 22.79%, fat content of 1.79%, solubility of 3.82%, L* value of 47.22 a* value of 11.15 and b* value of 22.07.

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