Addition of chitosan oligomers to improve bread texture

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Abstract. This study aimed to characterize the bread products that was given additional chitosan oligomer from crustacean (shrimp) waste. The making of bread with the addition of chitosan oligomer was carried out with concentration treatment (0, 0.1%, 0.3% and 0.5%) and the test parameters were chemical, physical (functional groups of chitosan oligomers, hardness with texture profile analyzer, and appearance of bread texture improvement using SEM tools) and sensory (hedonic). The results of chemical content of white bread showed that of moisture content ranged from 28.50% to 31.48%, protein content of 8.75% -10.85%, fat content of 5.87% -7.6% and carbohydrate (by different) of 48.77% to 56.88%. Analysis of hydroxyl groups in chitosan oligomers using FTIR displayed an absorption at a wavelength of 1437.7 cm⁻¹. Based on the results of hardness testing, the greater the concentration of chitosan oligomer added, the lower the hardness value of the resulting bread would be, making the texture softer. The results of SEM analysis showed that the addition of chitosan oligomer expanded more perfectly, especially in the addition of chitosan oligomer treatment by 0.3%. The overall hedonic test results on the bread gave insight that the addition of chitosan oligomer treatment by 0.3% was the most preferred.

Keywords: chitosan oligomer, crustacea, fresh bread, texture profile

1. Introduction

Chitosan is partially deacetylated because the deacetylation process is not perfect with varying degrees of polymerization [1]. Chitosan dissolves in most organic acid solutions with a pH of around 4.0 but does not dissolve at higher pH. Solvents that can be used are weak organic acids such as 10% acetic acid and 10% citric acid [2]. Chitosan is non-toxic, biodegradable, biofunctional, and has antimicrobial properties [3,6]. Chitosan can interact with charged materials such as proteins, anionic polysaccharides, weak acids, bile acids, and phospholipids. Chitosan has good physical, biological and chemical characteristics that are degradable, renewable and non-toxic [7]. Excess chitosan is the presence of hydrophobic and hydrophilic groups that are able to bind water and fat. Currently, chitosan oligomer is widely applied in the health sector as an anti-bacterial, anti-fungal and anti-virus food supplement that is useful for enhancing the immune system against diseases, helping health recovery after illness, preventing aging and emotional control, and various other claims of efficacy including anti-cancer, anti-diabetic, and other properties [8].

Chitosan oligomer is an oligomeric mixture of D-glucosamine which is formed through chitosan depolymerization process by breaking the β-glycosidic bond. Chitosan oligomers are chitosan which have been depolymerized so that they have smaller molecular size. Reducing the molecular weight of chitosan will cause greater solubility properties [8]. Oligocytosan is very interesting for researchers
because it can dissolve in water and has biological activity [8]. The presence of carboxyl groups is a strong indication of water-soluble chitosan. The results showed the yield of water-soluble chitosan between 118.0-129.4%, calculated against the weight of chitosan.

The depolymerization process occurs by breaking the β-glycosidic bond, so that it will have a smaller molecular weight than chitosan before depolymerization. Reducing the molecular weight of chitosan will cause greater solubility properties [8]. Chitosan oligomers are water soluble, so they can be applied in food products, especially in the form of food or drinks that are good for health. The use of chitosan and its modifications has been carried out commercially in the food industry, cosmetics, agriculture, pharmacy, health, waste management and water purification. In the food industry, chitin and chitosan are useful as preservatives, stabilizing the texture and color of products. The use of chitosan in food products can function as a source of dietary fiber that can trap fat molecules in the blood so that it can also function as a cholesterol-lowering agent. The use of chitosan oligomers in food and beverage products is expected to be an alternative for the development of food products that are good for health.

Fresh bread is one type of sponge-shaped food whose volume is composed mostly of gas bubbles. This product consists of gas as a discontinuous phase and solid as a continuous phase [9]. Based on the developer material used, bread is included in yeast-raised goods, a mixture that expands due to the presence of carbon dioxide produced by the fermentation process of sugar by yeast [10]. Bread making needs to pay attention to the balance between gas formation (gas production) and the ability to hold gas (gas retention), because these two things affect the quality of bread. There are two criteria for assessing the quality of fresh bread, namely external criteria, which include skin color (color of crust), privileges of form (symmetry of form), skin characteristics (character of crust), and cutting results, as well as other criteria, which include porosity (grain), color of crumb, aroma, taste, mastication and texture (Jacobs 1951). From some of these criteria the most commonly used to assess the quality of bread is porosity, texture, taste, and aroma. Porosity and texture are strongly influenced by the balance between gas formation and the ability to withstand gas. This study aimed to characterize the improvement of bread texture that was given additional oligomer chitosan from crustacean (shrimp) waste.

2. Materials and Methods

2.1. Materials
The raw material used in this study were chitosan oligomers obtained from the Biotechnology Department of Research Center for Marine and Fisheries Product Processing and Biotechnology. The chitosan oligomers were white, shaped as coarse flakes, and smelled slightly acidic.

2.2. Methods
In this study, the application of chitosan oligomer on bread to be carried out physically and analyzed chemically. The making of bread with the addition of chitosan oligomer was carried out with concentration and storage treatment at room temperature for six days. The process of making bread can be seen in figure 1.

Test parameters included sensory (hedonic and hedonic quality), physical (hardness) with the Texture Profile Analyzer (TPA), chemical (proximate), functional groups with Fourier-transform infrared spectroscopy (FTIR), and surface morphology with Scanning Electron Microscope (SEM).
3. Results and Discussion

Chitosan oligomers is a white powder and smells slightly acidic. At first, the oligomers were in the form of a solution, which was then processed using a freeze dryer to get the powder form. The results of the functional group analysis using FTIR tools are shown in figure 2.
FTIR Spectra of chitosan oligomers obtained from this study showed absorption at certain wavelengths based on the functional groups of chitosan oligomers. The data obtained showed the presence of amine groups, indicated by absorption at wave numbers 1573.91 cm\(^{-1}\). The hydroxyl group in chitosan oligomers was indicated by absorption at a wavelength of 1437.7 cm\(^{-1}\). Analyses of both shown for chitosan and chitosan oligomers spectrum [11].

The application of chitosan oligomer in bread is done by increasing the concentration of 0; 0.1; 0.3 and 0.5%. The results of the product can be seen in the figure 3.

![Figure 3](image)

**Figure 3.** (a) Fresh bread surface, (b) Baked bread with oligomer chitosan addition.

### 3.1. Hedonic quality test

The results of the hedonic quality test carried out on bread with the addition of chitosan oligomer are shown in figure 4. The concentration of chitosan oligomer added was 0.1%; 0.3% and 0.5% and 0% for the control.

![Figure 4](image)

**Figure 4.** Results of hedonic quality test of fresh bread. □ control; □ chitosan oligomer 0.3%; □ chitosan oligomer 0.1%; □ chitosan oligomer 0.5%.

In the appearance attribute, the addition of chitosan oligomer was significantly different from the control (without the addition of chitosan oligomer) with neutral and somewhat like criteria in all treatments. In the odor attribute, the treatment of chitosan oligomers with concentrations of 0.1% and 0.3% gave a higher hedonic quality with criteria rather like the controls. Texture attributes gave significant results, where 0.3% addition of chitosan oligomer treatment had the highest value with criteria approaching like. This was due to the additional bread given by chitosan oligomers that could hold water in the product so that the texture became softer. In the flavor attribute, the values given by the panelists were still in the neutral approach rather like the likes of all treatments, but the bread that was not given additional chitosan oligomer gave the lowest value compared to the bread with the addition of chitosan oligomer.
3.2. Hedonic test
The hedonic test (preference) as a whole was carried out on fresh bread products with the addition of chitosan and control oligomers. The results of the hedonic test are shown in figure 5.

![Hedonic test results for bread.](image)

The overall hedonic test results on the bread showed that the addition of chitosan oligomer treatment by 0.3% was the most preferred. This assessment was carried out as a whole, including appearance, smell, texture, and taste. The addition of other chitosan oligomers, namely 0.1% and 0.5% concentration, also gave a higher preference value compared to the control (white bread without the addition of chitosan oligomer).

3.3. Hardness test
Analysis of hardness/hardness was carried out using the TPA tool as shown in the figure 6. Hardness was one of the physical properties included in the texture attributes that is important in the assessment of food ingredients. Texture is the nature of a material that can be detected by the senses: eyes, skin, and taste [9]. Texture parameters are classified by the hardness, cohesiveness, viscosity, and elasticity [12]. The prominent textural nature of bread is soft, which is included in the parameters of hardness.

![Analysis of hardness using the Texture Profile Analyzer (TPA).](image)

The results of hardness/hardness analysis of bread showed that the addition of chitosan oligomer treatment had a significant effect on the product (figure 6).
Figure 7. The results of the hardness/hardness analysis of bread.

The greater the concentration of added chitosan oligomer, the lower the hardness value of the resulting white bread was. This shows that chitosan oligomers are able to slow down the decline in the quality of bread in terms of texture. This ability is related to the nature of chitosan in its ability to hold water in the product. This is in line with the previous research in which the addition of chitosan by 1% on baguette bread are shown to reduce the product hardness value for 36 hours of storage [13, 14].

3.4. Proximate analysis

Proximate analysis which includes water, protein and fat content is presented in the figure 8.

Figure 8. Fresh bread proximate analysis. ■ control; □ chitosan oligomer 0.1% ■ chitosan oligomer 0.3% ■ chitosan oligomer 0.5%.

The water content in fresh bread will affect the texture of the bread, or in this case the parameters used were the hardness of white bread. Flour that binds a little water will cause the dough to be elastic and stiff. The results showed that the addition of chitosan oligomer gave a significant effect by increasing the water content of fresh bread. The protein contained in the bread was affected by the type of flour used and the addition of milk. The flour used for making the bread was a type of hard wheat which was high in protein with high gluten content for development. The milk used in dough in addition to donating lactose to browning the bread of the bread would also contribute to a number of proteins in the bread. Fat content in fresh bread is was mainly influenced by the white butter used in the mixture.
3.5. Morphology SEM
SEM analysis of fresh bread products with the addition of chitosan oligomer is illustrated in figure 9.

![SEM images](image)

**Figure 9.** SEM analysis of fresh bread products (a) without addition of chitosan oligomer, (b) with the addition of 0.1% chitosan oligomer, (c) with the addition of 0.3% chitosan oligomer, (d) with the addition of 0.5% chitosan oligomer.

The SEM analysis on fresh bread demonstrated that the bread product without the addition of chitosan oligomers was not fully developed. The resulting texture also had many small holes which indicated that the cavity formation to trap water and CO₂ was not optimal. The addition of chitosan oligomer showed that the mixture expanded more perfectly, especially with the addition of chitosan oligomer treatment by 0.3%. The texture produced in the treatment had full and perfectly developed cavities. This was in accordance with the function of chitosan oligomers in dough, which had the ability to hold water and CO₂ so that the dough could expand well.

4. Conclusion

The addition of 0.3% chitosan oligomer treatment is the best in terms of the results of hardness, proximate and sensory analysis both hedonic and hedonic quality. The results of SEM analysis on fresh bread products proved that the addition of chitosan oligomer can improve the texture of white bread and its ability to hold water and CO₂ in the dough.

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