Review Article

Potential of Nanochitosan as an Edible Coating on Pangasius Fillet : A Review

ABSTRACT

Pangasius fillet are highly perishable foods and have a relatively short shelf life due to the quality degradation process. Nanochitosan is known to have the potential to protect fish fillets as an edible coating because it can penetrate deep into meat tissue and has high antibacterial activity. This article aims to produce good characteristics of nanochitosan (including: particle size, functional groups and particle morphology) and edible coating of nanochitosan (including: viscosity and transparency) as well as to analyze the effect of adding nanochitosan as an edible coating in inhibiting the deterioration of the quality of pangasius fillets during storage based on the total plate count (TPC) and organoleptic parameters according to the Indonesian National Standard 8606:2018.

Keywords: Pangasius fillet; nanochitosan; edible coating; characteristic.

1. INTRODUCTION

Pangasius in general are in great demand, especially in the global market, namely in the form of fillets or known as dory fillets Ikasari & Suryaningrum [1]. Fillets products are highly perishable foods Zega et al. [2]. Fish meat contains free amino acids and high water content to encourage the growth of bacteria which causes the quality of fish meat to decrease Chaillou et al. [3]. Bacterial growth can affect organoleptic properties such as the appearance, odor, and texture of fish so that it occurs in consumers Mei et al. [4] and causes product losses of up to 25-30% Hassoun & Emir Oban [5]. The cooling or cooling treatment is sufficient to prevent bacterial growth. Therefore, it is necessary to add preservatives to maintain the quality of fish during storage Erkan et al. 2015 [6].

In general, people will choose foods that use natural preservatives. Ideally, natural preservatives should have antibacterial activity, non-toxic, active at low concentrations, do not give color to the product, and environmentally friendly Carocho et al. [7]. Chitosan is a natural material derived from the extraction of crustacean shell waste Rochima [8] and is widely used as a natural preservative because it has antimicrobial, non-toxic, biodegradable, and biocompatible characteristics Zarandona et al. [9]. The presence of positively charged polycations from the amine group makes chitosan have good antimicrobial activity Verlee et al. [10].

Chitosan has been developed by modifying into nanoparticle size Rumengan et al. [11]. Chitosan nanoparticles are known to have extraordinary physicochemical characteristics and bioactivity so that they can be used as food preservatives, including fillet products Qiu et al. [12]. Nanochitosan has been proven to be effective as a preservative because of its small size that can penetrate deep into fish meat tissue and can enter bacterial cell membranes so that antimicrobial activity increases significantly Budhijanto et al. [13].

A study by Elkassas et al. [14] showing nanochitosan edible coating to maintain quality, extend shelf life, and inhibit bacterial growth in tilapia fish fillets (*Oreochromis niloticus*) during storage at 4℃ temperature, shows that nanochitosan edible coating are more effective than chitosan edible coating. In inhibiting the total bacteria and accepted by the panelists in the

organoleptic test and extending the shelf life of the tilapia fish fillet until the 10th day.

2. PANGASIUS FILLET

Fish meat is a source of protein that is rich in essential amino acids and high in omega-3 fatty acids Kulawik et al. [15]. Pangasius have an advantage over other fish products, namely their low-fat content Suryaningrum et al. [16]. Fat content of pangasius fish is 1,1% - 3% so it is in great demand by consumers, especially in the form of fillets Orban et al. [17]. Fish fillet is a fishery product in the form of fish meat that has been separated from the head, scales, entrails, bones, tail, and skin so that it's practical and easy to process Yuliana et al. [18]. However, fish fillet products have a relatively short shelf life due to the quality degradation process. The decrease in quality is generally caused by autolysis, enzymatic activity, fat oxidation, and microorganism activity Ramezani et al. [19]

3. EDIBLE COATING

The edible coating is a layer of material that can be consumed by being applied directly to the surface of the product which serves to increase shelf life and as a carrier of food substances such as antioxidants, vitamins, minerals, preservatives, antimicrobials, and ingredients to improve the color and taste of packaged products Nur et al. [20]. Research by Rathore & Pradhan [21] the quality of edible coating can be improved by adding nano-sized fillers.

4. CHITOSAN

Chitosan is a compound from the deacetylation of chitin, composed of N-glucosamine and N-acetyl glycosamine units. The reactive amino group is at the C-2 atom and the hydroxyl group is at the C-3 and C-6 atoms Rochima [8]. Meanwhile, chitosan has attracted attention in various fields of science because of its biocompatible, biodegradable, non-toxic, and anti-bacterial properties

Table 1. Chitosan Quality Standard

Parameter	Standard	
	Dalwoo Korea	**Lab. Protan Jepang**
Apparition	White or yellow powder	Clear solution
Particle size	25-200 mesh	Flakes to powder
Water content	≤ 10%	≤ 10%
Ash content	≤ 0,5%	≤ 2%
Protein content	≤ 0,3%	-
Degree of Deacetylation (DD)	≤ 70%	≤ 70%
Viscosity	50-500 cps	200-2000 cps
Insoluble	≤ 1%	-
Heavy metal content: As, Pb	≤ 10 ppm	-
pH	7-9	7-8
Smell	No smell	No smell

Source : Rochima [8]

The degree of deacetylation (DD) is a quality parameter of chitosan with the percentage of loss of acetyl groups from the chitosan yield so that the higher the DD of chitosan, the lower the chitosan acetyl groups, making the interaction between hydrogen bonds and ions increase Rochima [8]. Chitosan has antibacterial activity. The mechanism of chitosan as an antibacterial is that chitosan molecules will interact with compounds on the surface of bacterial cells and then are absorbed to form a layer that inhibits cell transport channels so that the substance to proliferate will be reduced which causes the bacterial cells to die Yulia & Arumsari [22]. Chitosan can be applied, one of which is as a coating material on fish fillets. Damayanti et al. [23] reported that the addition of a concentration of 2% chitosan as an edible coating can maintain the quality of Pangasius fillets up to day 11 at low-temperature storage with a total bacteria of 6.7×10^5 cfu/g, pH 6.67, and shrinkage. weight as much as 6.78% and higher antimicrobial

properties in Escherichia coli bacteria (Gram-negative).

4. NANOCHITOSAN

Nanoparticles are natural or artificial polymers with a size of 10-1000 nm Mohanraj et al 2006 in Handayani et al. [24]. Nano-sized materials have better properties than base materials Yanat & Schroën [25]. Nanoparticles are very potential as an edible coating or film to protect food ingredients Rosyada et al. [26]. The use of nanoparticle technology can be applied to natural polymers such as chitosan by changing to nanoparticle size so that it will increase absorption which will expand the surface of the chitosan Nasution et al. [27.

Table 2. Application of edible coating nanochitosan on various fish fillets

Fish Fillets	Treatment	Best treatment	Observation		Source
Trevally fish	1% acetic acid, 2% chitosan dan 2 % nanochitosan.	2% nanochitosan	4℃	12 days	Alboghbeish & Khodanazary [28]
Lingua fish	1% acetic acid, 2% chitosan dan 2 % nanochitosan.	2% nanochitosan	-3 ℃	16 days	Ghorabi & Khodanazary [29]
Tilapia fish	1% acetic acid, 1% dan 2% kitosan, 1% dan 2% nanokitosan	2% nanochitosan	4 ℃	10 days	Elkassas et al.[14]
Tuna fish	1,2,3 (%) nanochiitosan dan 1 % chitosan	2% nanochitosan	27℃	12 hours	Rasulu et al. [30]

5. NANOCHITOSAN AS EDIBLE COATING

Nanochitosan has extraordinary bioactivity in food preservation and can be applied to fresh fish products as edible coating or film as natural preservatives that are safe for health Qiu et al. [12]. The application of nanochitosan as an edible coating can give a better effect than ordinary-size chitosan. The results of the study Ramezani et al. [19] showed that the addition of 2% nanochitosan showed higher antimicrobial activity than regular-size chitosan on silver carp fish fillets at low-temperature storage and other research results as shown in table 2 the antibacterial ability of nanochitosan can be better compared to regular size chitosan because chitosan that has been modified into nanoparticles has a smaller size and specific surface so that it can easily enter bacterial cells Magani et al. [31].

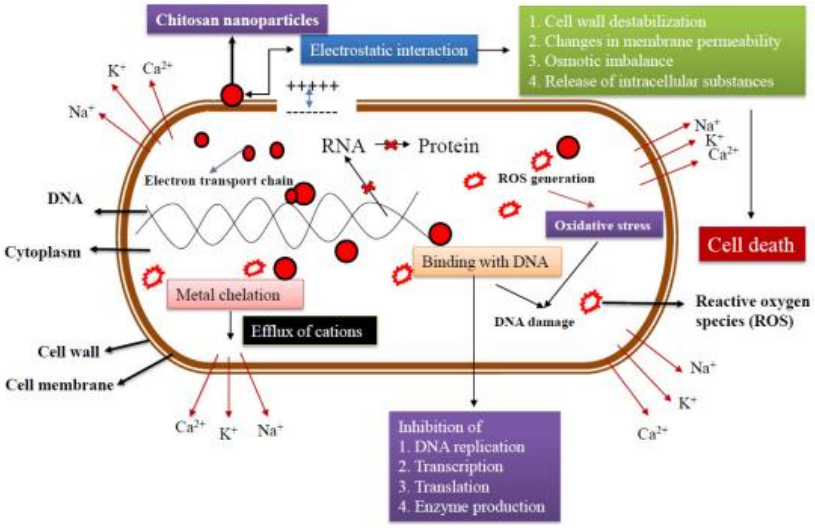

Figure 1. Nanochitosan Antibacterial Mechanism
Source: Chandrasekaran et al. [32]

Figure 1 shows the antibacterial mechanism of nanochitosan which shows that the electrostatic interaction between nanochitosan and bacterial cell walls results in infiltration or entry of nanochitosan through the cell wall into bacterial cell Chandrasekaran et al. [32]. Chitosan that enter bacterial cells is able to change the membrane electron transport chain which functions to produce electron carriers and build a proton gradient on the inside of the mitochondrial membrane which is important for ATP production, causing cell death Rozman et al. [33] .

6. CHARACTERIZATION NANOCHITOSAN

6.1 Nanochitosan Particle Size

The particle size analysis of nanochitosan was tested using a Particle Size Analyzer (PSA) using the Dynamic Light Scattering (DLS) method. The DLS principle is a particle measurement based on a brown motion by detecting the random motion of particles in a liquid medium so that the particle size distribution in the sample can be known Rosyada et al. [26]. The good particle size for nanochitosan is below 1000 as described by Mohanraj et al (2006) in Handayani et al. [24] Nanoparticles are natural or artificial polymers with a size of 10-1000 nm. Particle size is an important factor in the application of nanochitosan because it affects the biocompatibility of the particles and the rate of absorption either into bacterial cells or into fish flesh tissue Feng et al. [34].

6.2 Nanochitosan Functional groups

Functional group analysis aims to find out information on the presence of functional groups in certain compounds. Fourier Transform Infrared (FTIR) is an analytical technique that can be used to characterize samples in both liquid and solid/dry forms. Characterization analysis using FTIR has good accuracy and fast analysis time Nandiyanto et al. [35]. A good characteristic of the functional group of nanochitosan is that it has a unique functional group of chitosan, namely the O-H, N-H, C-H, C=O, and C-N functional groups and there is a P=O functional group which shows the phosphate group of Na-TTP in nanochitosan as an indication of a cross between Na- TTP and chitosan through ionic bonds indicate that a solution of nanoparticles has been formed Balde et al. [36].

6.3 Nanochitosan Particle Morphology

The morphology of nanochitosan can be known through the Scanning Electron Microscopy (SEM) tool. The working principle of SEM is that the electron gun will produce an electron beam then the electron will be accelerated to the sample, then the electrons that have focused on scanning the entire sample and are directed by the scanner coil, when the electrons hit the sample, the sample will release new electrons which are received by the detector which then sent to a monitor (CRT) Ningrum et al. [37]. The good morphology of nanochitosan is spherical and uniform in shape and has a nanoparticle size Agarwal et al. [38].

7. EDIBLE COATING CHARACTERISTICS

7.1 Edible Coating Viscosity

Characterization of viscosity on edible coating nanochitosan can be measured using a Brookfield viscometer with spindle no 3 at a speed of 30 rpm with units of centipoise (cP). Viscosity analysis aims to determine the level of viscosity in a solution Nurmilla et al. [39]. Viscosity in edible coating will affect their application to food products. In the food industry, chitosan edible coating are needed which have a low viscosity value Vatria et al. [40]. If the viscosity of the edible coating is too thick, it will be difficult to use it to diffuse with food and can cause anaerobic respiration so that the food will decompose faster. Therefore, the viscosity value is expected to be following a good viscosity value standard of 113-255 cP Anggarini et al. [41].

7.2 Edible Coating Transparency

The characteristics of transparency can be measured using a wavelength of 185-760 nm. The working principle of transparency testing is to absorb the compound at a certain point at a wavelength using a UV-Vis spectrophotometer Apriliyani et al. [42]. Transparency describes the level of clarity of the resulting suspension. The transparency of edibles tends to increase as the concentration of active ingredients in edibles increases, so it will reduce the degree of clarity of the edibles produced Warkoyo et al. [43]. Edible coating should have a low transparency value as packaging for a food ingredient because it is important from a marketing perspective that will affect consumer judgments in terms of product aesthetics Wang et al [44].

8. APPLICATION OF EDIBLE CAOTING NANOCHITOSAN ON PATIN FILLET

8.1 Total bacteria

Microbiological characteristics can be used as a measure of the freshness of fish Stratev et al. [45]. The microbiological test is important because it can detect the shelf life of food and is an indicator of food sanitation and safety. Microbial contamination of a food product and whether it is safe for consumption is determined by its microbiological quality which can be identified through microbiological testing. One of them can be done using the Total Plate Count (TPC) method Sukmawati et al. [46]. A total plate number is a number that represents the number of mesophyll bacteria in every 1 gram or 1 ml of the food sample being examined. The food samples were grown on the growth media plate by the appropriate pouring method and then incubated at 35-37℃ for 24-48 hours. The total number of bacteria allowed in the Pangasius fillet according to the Indonesian National Standard (SNI) 8606:2018 is $5x10^5$ cfu/g National Standardization Agency [47].

8.2 Organoleptic Scroring Test

The scoring test is one of the scalar tests in organoleptic testing. Each parameter that has been determined for the sample is assigned an assessment. The scoring test can be used to compare and measure similar products by assigning a value or score to the product Tarjoko et al. [48]. Scoring organoleptic testing is an important parameter for early detection in assessing quality to determine changes and deviations in the product. The scoring test can also be used to determine the parameters of quality deterioration in fish Vatria et al. [40]. The minimum organoleptic score on Pangasius fillets according to the Indonesian National Standard (SNI) 8606:2018 with observation parameters namely appearance, texture, and aroma on a quality number scale of 9, 7, and 5 with the condition that the minimum organoleptic quality value is 7.0, which means if the value is less than 7 then the fish fillet is declared unfit for consumption National Standardization Agency [47].

9. CONCLUSION

Pangasius fillets are in great demand in local and global markets and are one of the export commodities that have high economic value. However, the Pangasius fillet product is included as highly perishable food, so if it is not handled properly it can cause up to 25-30% loss in the product. The use of nanochitosan as an edible coating has the potential to protect fish fillets because it can penetrate deep into the meat tissue and has high antibacterial activity. The use of nanochitosan edible coating depends on the characteristics of the nanochitosan and the edible coating. Good characteristics of nanochitosan have a particle size of 10-1000 nm, have functional groups typical of chitosan, namely functional groups O-H, N-H, C-H, C=O, C-N, and have a uniform round shape morphology, while the characteristics of a good edible coating are having a viscosity value of 113- 255 cP and a low transparency value. The quality standard for Pangasius fillets refers to the Indonesian National Standard (SNI) 8606:2018, namely the total plate Count (TPC) of bacteria below $5x10^5$ cfu/g and a minimum organoleptic score of 7.00. Based on several studies, the addition of nanochitosan as an edible coating on fish fillets can maintain the quality during the

shelf life and has better antibacterial activity than regular-size chitosan. Nanochitosan can be used as an edible coating to maintain the quality of Pangasius fillets during their shelf life.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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