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Mechanical, Optical, and Microbiological Characteristics of Biocomposite Edible Film Based on Canna Starch and Nanochitosane with the Addition of Fish Oil: A Review

Shafira Nur Rahmatunnisa [a*], Emma Rochima [a], Sunarto [a] and Rusky Intan Pratama [a]

[a] *Fisheries Departement, Faculty of Fisheries and Marine Science, Padjadjaran University, JL Raya Bandung-Sumedang KM 21, Jatinangor, Sumedang 45363, West Java, Indonesia.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Edible film is a packaging development for environmentally friendly food that is composed of organic ingredients, so it is safe for consumption. Natural polymers that make up edible films include polysaccharides, lipids, and proteins to replace synthetic packaging materials. The characteristics of good edible film have properties like other plastic packaging, namely being easy to shape, transparent, flexible, not easily damaged, and cheap. Canna starch has the potential to be used as a building material because it contains high levels of amylose and amylopectin, and

**Corresponding author: Email: shafiranrahmatunnisa@gmail.com;*

nanochitosan has good antimicrobial activity. The addition of fish oil to edible films is a solution to correct the deficiencies of edible film biocomposites, which can increase their hydrophobic properties and tensile strength.

Keywords: Edible film; biocomposite; characteristics; canna starch; nanochitosan; fish oil.

1. INTRODUCTION

Increased consumer interest in safety, convenience, food stability, and awareness of the negative environmental impact of non-biodegradable packaging such as plastic has led to the development of edible coatings [1]. Edible film is a thin layer that has a thickness of less than 0.3 mm and functions to protect food products [2]. Renewable materials making up edible films include polysaccharides, lipids, or proteins to replace synthetic packaging materials [3].

Starch is a polysaccharide whose existence is very abundant because it comes from plants [4]. The composition of starch consists of anhydroglucose residues, straight-chain amylose, and amylopectin, which is a polymer of glucose with a branched chain structure [5]. The use of starch in the manufacture of edible films and coatings is often carried out because it generates transparent, odorless, tasteless, and is a good barrier to protect from O_2 and CO_2 gases [6].

Chitosan, another polysaccharide, is also one of the polymers that can be used as a constituent of edible films. The use of chitosan continues to grow, including the physical modification of chitosan to produce nanoparticles [7]. The addition of chitosan nanoparticles as nanofillers in starch films can also improve their physicochemical properties as well as have an antimicrobial function [8]. Edible films based on polysaccharides such as starch and chitosan, both of which exhibit poor water vapor barrier properties and tensile strength, are easily brittle films [9]. Lipids can be used as additives added to films containing polysaccharides or proteins to increase the hydrophobic properties of the resulting biocomposite edible films [10].

Fish oil contains fatty acids that are rich in benefits because they contain around 25% saturated fatty acids and 75% unsaturated fatty acids, which are the result of extraction from fish waste as a source of omega 3, especially EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) [11]. The addition of lipids in the manufacture of edible films has been shown to reduce water vapor permeability and have a significant effect on mechanical properties and transparency [12].

Based on information, it can be seen that biocomposite edible films made from starch, nano-chitosan, and fish oil can improve the characteristics of edible film so as to have the effect of extending the product’s shelf life when packaged.

2. EDIBLE FILM COMPONENTS

Edible films can be produced by proteins (gluten, collagen, gelatin, keratin, casein, and soy), polysaccharides (cellulose, tapioca, alginate, pectin, and carrageenan), lipids (waxes, triglycerides, oils, and fatty acids), and composites. The addition of additives such as plasticizers, antioxidants, vitamins, antimicrobials, essential oils, and chemical preservatives is used to increase the protective properties of edible films and coatings [5].

2.1 Canna Starch

Canna starch comes from the tubers of the canna plant (Canna edulis Kerr), which can be found in almost all parts of Indonesia, both in the lowlands and highlands [13]. Canna starch contains high levels of carbohydrates and has the potential to be processed into food products, with a total starch content of 93.30%, an amylose content of 42.49%, and an amylopectin content of 50.90% [14]. The chemical structure of starch constituents can be seen in Fig. 1.

Pure cannabidiol starch or modified cannabis can be used in the preparation of perfect edible films. This is because canna starch has a relatively high ratio of amylose and amylopectin [15]. The addition of cannabidiol and glycerol from used cooking oil significantly affects the physical and mechanical characteristics [16].

2.2 Nano Chitosan

Chitosan is a polysaccharide of N-acetyl D-glucosamine and D-glucosamine units and is mainly obtained by partial deacetylation of chitin [17]. Chitosan is biocompatible and biodegradable, even very abundant on earth with its biodegradability in both water and soil [18]. The chemical structure of chitin and chitosan can be seen in Fig. 2.

Nano-chitosan can be obtained by a variety of methods depending on factors including the desired particle size, particle kinetic profile, chemical and thermal stability of the particles, and residual toxicity related to the final product [19]. The addition of nanochitosan to edible films can increase the rigidity of the polymer, which confirms the effect of nanoparticle stiffness on the polymer matrix [20]. Nanochitosan suspension has the potential to be applied as a filler that can increase antibacterial activity in edible films [21].

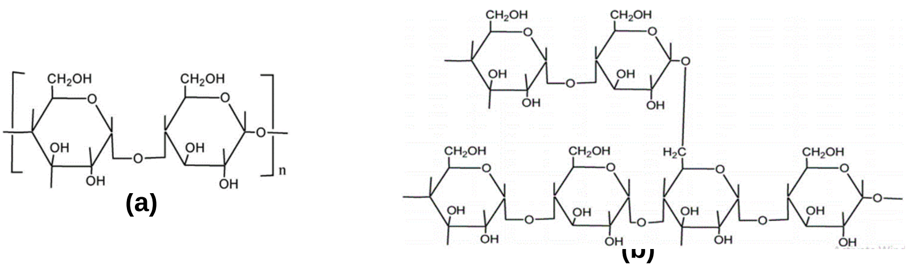
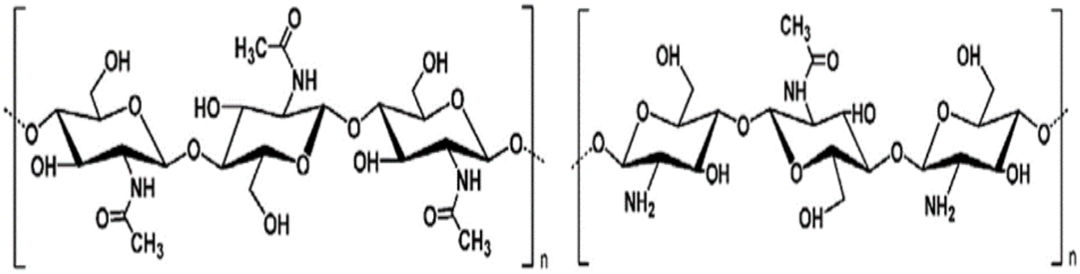


Fig. 1. Chemical Structures of Amylose (a) and Amylopectin

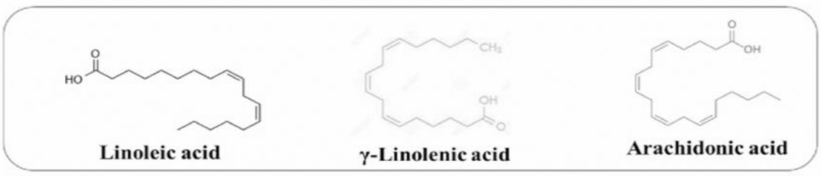
Source: Hassan et al. [6]



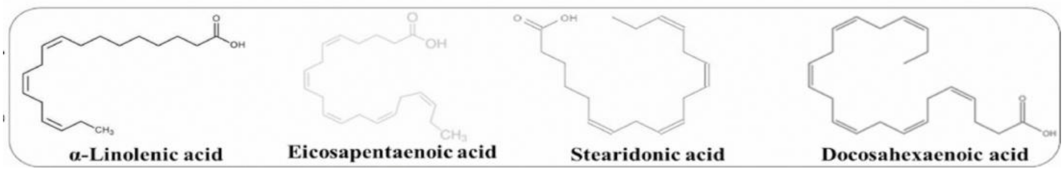
(a) **(b)**

Fig. 2. Chemical Structure of Chitin (a) and Chitosan (b)

Source: Kumar et al. [16]



(a)



(b)

Fig. 3. Structure of Omega-6(a) and Omega-3(b) Fatty Acids

Source: Patel et al. [24]

2.3 Fish Oil

Lipids derived from fish rich in eicosapentanoic acid (EPA) and docosahexanoic acid (DHA) vary depending on species and habitat. Freshwater fish show high EPA levels, while marine fish are rich in EPA and DHA [22]. Marine fish, especially those that eat zooplankton, are a source of omega-3 fatty acids, while freshwater fish that eat phytoplankton, algae, and plants are a source of omega-6 fatty acids [23]. The structure of Omega-6 and Omega-3 can be seen in Fig. 3.

Oil extraction is a way to obtain oil or fat from materials that contain oil or fat [25]. Fish oil and vitamin C on gelatin-based edible films using the spinning method have the potential to add hydrophobic and hydrophilic nutrients [26]. Fish oil added to the chitosan edible film had a significant effect on reducing fungal growth [27].

3. CHARACTERISTICS OF EDIBLE FILM

Based on the Japanese Industrial Standard (1975) in Khotimah and Tjahjani [28], good food product packaging must meet quality requirements. The standard specifies characteristics including thickness, tensile strength, percent elongation, and water vapor transmission rate.

3.1 Mechanical

The mechanical properties of edible films affect the flexibility of the films produced; the smaller the value of the tensile resistance and the greater the elongation value of the edible film, the more applicable [30]. Packaging films must have adequate mechanical performance to protect food, maintain integrity, and extend the shelf life of food. Therefore, the mechanical properties of edible films are an important aspect to pay attention to [31].

Table 1. Edible Film Characterization According to Japan Industrial Standards

Parameters	Value
Tensil strength	Min. 0,39 MPa
Thickness	Maks. 0,25 mm
Elongation	<10% is very poor >50% is very good
Water vapor transmission	Maks. 7 g/m^2/day

Source: Melinda [29]

3.2 Optical

Optical properties are an important parameter as they affect consumer acceptance of film and packaged food products [32]. Transparent edible films are usually preferred because of their higher acceptance and application in food packaging systems [33]. Film transparency is one of the physical properties that can affect its appearance and usability [34].

3.3 Microbiological

Food spoilage is a food contamination process that makes the quality of the product deteriorate so much that it cannot be eaten [35]. Antibacterial compounds are substances that inhibit or kill growth by interfering with the metabolism of harmful bacteria [36]. By using antimicrobial materials to determine the film's ability to inhibit antimicrobial activity [37].

Table 2. Biocomposite edible film research

Title	Reference	Result
Effect of the fish oil fortified chitosan edible film on microbiological, chemical composition and sensory properties of gobek kashar cheese during ripening time	Yangilar [27]	- The addition of fish oil to chitosan edible film has been shown to have a significant effect on reducing mold on cheese coated with chitosan film enriched with 1% fish oil.
Development of Composite Edible Film Based on Corn Starch with Addition of Palm Oil and Tween 20	Santoso et al. [38]	- Treatment of palm oil concentration significantly affected thickness, percent elongation, water vapor transmission rate, and water content. - Tweens and 20 have a significant impact on
Characterization of Biocomposite Edible Films Based on Cassava	Debora et al. [12]	- The addition of oleic acid to changes in the characteristics of edible films has a

Title	Reference	Result
Starch, Gelatin, and Nanochitosan with the Addition of Oleic Acid		significant effect on the physical properties, tensile strength, and transparency of the film but has no significant effect on the percent elongation.
Effect of Clove Oil Concentration on the Edible Film Characteristics of Cassava Starch - Chitosan	Ulyarti et al. [39]	- The addition of clove oil causes transparency to decrease. - Edible film that is cloudy in color can block light from entering.
Effects of cinnamon essensial oil on the physical, mechanical, structural and thermal properties of cassava starch-based edible films	Zhou et al. [40]	- The plasticization of cinnamon oil significantly increased the elongation at break and improved the ductilty of the film. - The UV-barrier property, oxygen barrier property, and water resistance of the film also increased with the increase of cinnamon oil content.

4. BIOCOMPOSITE EDIBLE FILM WITH THE ADDITION OF FISH OIL

Edible biocomposite films are edible films consisting of hydrocolloid biopolymers combined with lipids [38]. Lipids can be used as additives added to films containing polysaccharides or proteins to increase the hydrophobic properties of the resulting biocomposite edible film [10]. Research on biocomposite edible films can be seen in Table 2.

5. CONCLUSION

Edible film is a coating material that can be eaten and applied as a food packaging material. Edible films composed of natural polymers such as starch and chitosan exhibit poor water vapor barrier properties and mechanical characteristics at tensile strength. Lipids such as fish oil that are added to the film can increase the hydrophobic properties and tensile strength of the resulting biocomposite edible film.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Dehghani S, Hosseini SV, Regenstein JM. Edible films and coatings in seafood preservation: A review. Food Chemistry. 2018;240:505–513.
2. Paul SK. Edible films and coatings for fruits and vegetables. Encyclopedia of Renewable and Sustainable Materials. Elsevier Ltd.; 2020.
3. Pająk P, Przetaczek-rożnowska I, Juszczak L. Development and physicochemical, thermal and mechanical properties of edible films based on pumpkin, lentil and quinoa starches. International Journal of Biological Macromolecules; 2019.
4. Menzel C. Starch structures and their usefulness in the production of packaging materials. Doctoral Thesis. Faculty of Natural Resources and Agricultural Sciences. Swedish University of Agricultural Sciences. Swedish; 2014.
5. Hassan B, Chatha SAS, Hussain AI, Zia KM, Akhtar N. Recent advances on polysaccharides, lipids, and protein based edible films and coating. Review: International Journal of Bological Macromolecules. 2018;109:1095-1107.
6. Erkmen O, Barazi AO. General characteristics of edible films. Journal of Food Biotechnology Research. 2018; 2(1.3):1–4.
7. Nadia LMH, Suptijah P, Ibrahim B. Production and characterization chitosan nano from black tiger shrimpwith ionic gelation methods. Journal of Processing of Indonesian Fishery Products. 2014;17(2): 119–126.
8. Qin Y, Zhang S, Yu J, Yang J, Xiong L, Sun Q. Effects of chitin nano-whiskers on the antibacterial and physicochemical properties of maize starch films. Carbohydrate Polymers; 2016.
9. Pacheco N, Naal-Ek MG, Ayora-Talavera T, Shirai K, Román-Guerrero A, Fabela-Morón MF, Cuevas-Bernardino JC. Effect of bio-chemical chitosan and gallic acid into rheology and physicochemical properties of ternary edible films.

International Journal of Biological Macromolecules. 2019;125:149–158.
10. Jeevahan J, Chandrasekaran M. Nanoedible films for food packaging: a review. Journal of Materials Science. 2019;54 (19):12290–12318.
11. Rozi A, Ukhty N, Khairi I, Irhamdika I, Meulisa AI, Bija S. Fatty acid characterization of liver oil from shark (*Centrophorus* sp.) using dry rendering extraction method. Journal of Processing of Indonesian Fishery Products. 2019;22 (3):414–422.
12. Debora K, Rochima E, Panatarani C. Effect the addition of oleic acid on water barrier properties of edible film. Global Scientific Journals. 2020;8(2):3832–3837.
13. Santoso B. Edible film: Technology and its applications. NoerFikri: Palembang. 178 hlm. 2020;1.
14. Fatkhiyah N, Kurniasari L, Riwayati I. Modification of canna tuber starch (*Canna edulis* Kerr) by cross linking using sodium trioliphosphat (STPP). Chemical Engineering Innovation. 2020;5(2): 81–86.
15. Santoso B. Integration of modified starch, surfactants, proteins, and catechins in the manufacture of edible films. Dissertation of the Agricultural Industry Study Program, Postgraduate Program, Sriwiya University, Palembang; 2011.
16. Suharyanto dan Setiyako. Physical and mechanical characteristics of canna starch (*Canna edulis* Kerr) Edible Film with Plasticizer from Used Cooking Oil Glycerol. Universitas Mercu Buana. Yogyakarta; 2021.
17. Kumar S, Mukherjee A, Dutta J. Chitosan based nanocomposite films and coatings: Emerging antimicrobial food packaging alternatives. Trends in Food Science and Technology. 2020;97: 196–209.
18. Husni P, Junaedi J, Gozali D. Potential of chitosan sourced from crab shell waste (*Portunus pelagicus*) in the Pharmaceutical Sector. Majalah Farmasetika. 2020; 5(1):32–38.
19. Agnihotri SA, Mallikarjuna NN, Aminabhavi TM. Review on recent advances on chitosan based micro and nanoparticles in drug delivery. Journal of Controlled Release. 2004;100(1):5-28.
20. Antoniou J, Liu F, Majeed H, Zhong F. Characterization of tara gum edible films incorporated with bulk chitosan and chitosan nanoparticles: A comparative study. Food Hydrocolloids. 2015;44. Hlm. 309-319.
21. Rochima E, Azhary SY, Pratama RI, Panatarani C, Joni IM. Preparation and characterization of nanochitosan from crab shell waste by beads-milling method. Materials Science and Engineering; 2017.
22. Hamilton HA, Newton R, Auchterlonie NA, Müller DB. Systems approach to quantify the global omega-3 fatty acid cycle. Nature Food. 2020;1:59–62.
23. Sun S, Ren T, Li X, Cao X, Gao J. Biochemical and biophysical research communications polyunsaturated fatty acids synthesized by freshwater fi sh : A new insight to the roles of elovl2 and elovl5 in vivo. Biochemical and Biophysical Research Communications. 2020;532(3): 414–419.
24. Patel A, Karageorgou D, Katapodis P, Sharma A, Rova U, Christakopoulos P, Matsakas L. Trends in food science & technology bioprospecting of thraustochytrids for omega-3 fatty acids : A sustainable approach to reduce dependency on animal sources. Trends in Food Science & Technology. 2021; 115:433–444.
25. Eka B, Junianto, Rochima E. Effect of rendering method on physical, chemical and organoleptic characteristics of crude catfish oil extract. Journal of Marine Fisheries. 2016;7(1):1–5.
26. Liu L, Tao L, Chen J, Zhang T, Xu J, Ding M, Zhong J. Fish oil-gelatin core-shell electrospun nanofibrous membranes as promising edible films for the encapsulation of hydrophobic and hydrophilic nutrients. Lwt. 2021;146: 111500.
27. Yangilar F. Effect of the fish oil fortified chitosan edible film on microbiological, chemical composition and sensory properties of göbek kashar cheese during ripening time. Korean Journal for Food Science of Animal Resources. 2016; 36(3):377–388.
28. Khotimah I, Tjahjani S. Improving the mechanical properties of edible film from soybean meal using chitosan-sorbitol as food product packaging. UNESA Journal of Chemistry. 2020;9(2): 144–150.
29. Melinda E. Characterization of edible film based on jackfruit seed starch (*Artocarpus heterophyllus* Lmk) with the addition of CMC (Carboxymethyl Cellulose) and glycerol concentrations. Thesis. Food

Science and Technology Study Program. Malang Muhammadiyah University. Malang; 2019.

30. Dwimayasanti R. Utilization of carrageenan as edible film. Oceana Journal. 2016; 41(2):8-13.
31. Wang H, Ding F, Ma L, Zhang Y. Food bioscience edible films from chitosan-gelatin : Physical properties and food packaging application. Food Bioscience. 2021;40(1):1–17.
32. Cheng Y, Sun C, Zhai X, Zhang R, Zhang S, Hou H. Effect of lipids with different physical state on the physicochemical properties of starch / gelatin edible films prepared by extrusion blowing. International Journal of Biological Macromolecules. 2021;185:1005–1014.
33. Suderman N, Isa MIN, Sarbon NM. The effect of plasticizers on the functional properties of biodegradable gelatin-based film: a review. Food Bioscience. 2018; 24(9):111–119.
34. Dai, Limin, Zhang J, Cheng F. Effects of starches from different botanical sources and modification methods on physicochemical properties of starch-based edible films. International Journal of Biological Macromolecules. 2019;132:897–905.
35. Malhotra, Bhanu, Keshwani A, Kharkwal H. Antimicrobial food packaging: Potential and pitfalls. Frontiers in Microbiology. 2015;6(JUN):1–9.
36. Anggraini TN, Agustini TW, Rianingsih L. Garlic extract (*Allium sativum*) as antibacterial. Fisheries Science. 2018; 14(1):70–76.
37. Motelica, Ludmila D, Ficai A, Ficai OC, Oprea DA, Kaya, Andronescu E. Biodegradable Antimicrobial Food Packaging: Trends and Perspectives. Foods. 2020;9(10):1–36.
38. Santoso B, Amilita D, Priyanto G, Hermanto H, Sugito S. Development of composite edible film based on corn starch with addition of palm oil and tween 20. Agritech. 2018;38(2):119.
39. Ulyarti, Rizki, Mursyid M, Rahmayani I, Suseno R, Nazarudin. Effect of clove oil concentration on edible film characteristics of cassava starch – chitosan. Journal of Agricultural Technology. 2022;11(2):129 – 138.
40. Zhou Y, Wu X, Chen J, He J. Effects of cinnamon essensial oil on the physical, mechanical, structural and thermal properties of cassava starch-based edible films. International Journal of Biological Macromolecules. 2021;184:574 – 583.

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