Review Article

PHYSICAL CHARATERISTICS OF BIOCOMPOSITE EDIBLE FILM BASED ON STARCH AND NANOCHITOSAN WITH THE ADDITION OF OIL AND ACIDS: A REVIEW

.

ABSTRACT

Edible film is a type of edible packaging in the form of a thin layer to protect food products and can be decomposed naturally so that it can be an alternative to the use of plastic packaging. Edible film components consist of hydrocolloids (polysaccharides, proteins), lipid, or a combination of these materials with or without the addition of plasticizers. The physical characteristics of edible film that are commonly used are thickness, tensile strength, elongation, water vapor transmission rate, and solubility. Several studies have shown that the addition of fish oil as lipid to starch and nano-chitosan edible film can improve the physical characteristics of the film. The addition of a greater concentration of fish oil can increase the thickness value and decrease the water vapor transmission rate and water solubility of the edible film.

Keywords: Edible film, physical characteristics, oil, acids, chitosan, and starch.

1. INTRODUCTION

Edible film is a thin layer of edible packaging which is made to protect food and aimed to be decomposed naturally. This may be an alternative to plastic packaging that is widely used today.Edible film are composed of natural ingredients such as hydrocolloids (polysaccharides or proteins), fats, and some are composed of a combination of these materials with or without the addition of plasticizers [1]. Edible film composed of only one material such as hydrocolloid materials still have weaknesses such as low barrier properties, brittleness, and low tensile strength [2]. The combination of several constituent components or also called composite edible film can be a solution in overcoming the deficiencies of each constituent [3]. Edible biocomposite film is a combination of natural hydrocolloid polymers and lipid to form film. The building blocks for hydrocolloid edible film include hydrocolloids (starch and chitosan) and lipid [4].

Starch is an abundant natural polysaccharide in nature since it comes from plants. Commonly, the starch extraction is coming from tubers, roots and seeds of plants which have a role as food reserves [5]. Starch contains two main components which are amylose and amylopectin. Both components contain D-glucopyranose that are linked by α-1,4 glycosidic bonds in the main chain and connected by α-1,6 glycosidic bonds in the branch chains [6].As a constituent of edible film, starch is known to act as a thickener and binder in edible film containing amylose and amylopectin [7].

Chitosan as another polysaccharide is also one of polymers that can be used as a constituent of edible film. It is generally used as a thickener and stabilizer. Moreover, chitosan also develops gel and texture in a substance.Another property of chitosan is that it forms a film and is easily degradable, making it suitable for making edible film [7]. Chitosan has also been modified into a nano form, the addition of nano chitosan into the edible film formulation as a nanofiller can improve the mechanical properties, film color, and water vapor permeability of the edible film compared to ordinary edible film or without the addition of nano materials [8]. Pacheco *et al.* 2019 [9] explained in his research that the edible film composed of starch and chitosan still has weaknesses such as low barrier properties, brittle and low tensile strength. Therefore, additional ingredients such as lipid are needed which are hydrophobic and are known to improve the properties of edible film in holding water vapor or moisture [10].

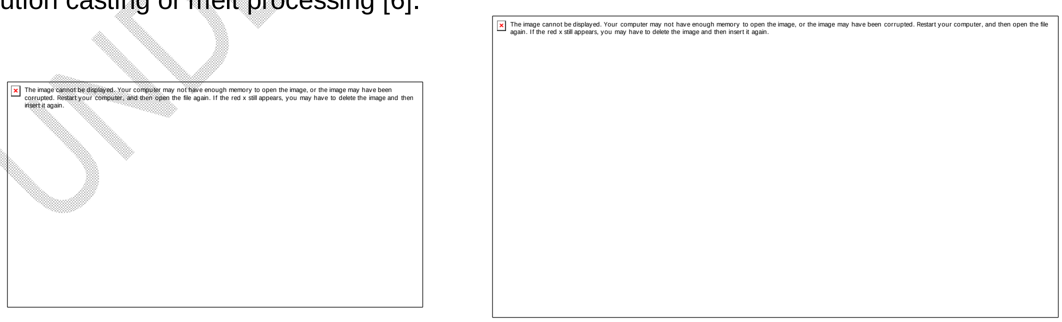
Edible film added with lipid are known to have low water vapor permeability values, but there are still deficiencies in their mechanical and optical properties because the resulting edible film are relatively thick and break easily [11]. Based on this information, it can be seen that biocomposite edible film made from starch, nano chitosan, and fish oil can improve physical properties, especially the rate of water vapor transmission, thereby extending shelf life and improving product quality when packaged.

2. COMPONENTS OF EDIBLE FILM

Edible film components consist of hydrocolloids, lipid, and some are composed of a combination of these ingredients with or without the addition of plasticizers [1].The types of hydrocolloids commonly used in the preparation of edible film are polysaccharides (cellulose, starch, pectin, seaweed extract, guar gum, pullulan, and chitin/chitosan) and proteins (gelatin, soy protein, zein, wheat gluten, myofibrillar protein, and protein milk). The types of lipid used as ingredients for making edible film include natural waxes, vegetable oils and fats, animal oils and fats, essential oils and extracts, and resins [8].

2.1 Starch

Starch is a natural polysaccharide whose existence is very abundant in nature because it comes from plants. The main source of starch extraction is found in tubers, roots and plant seeds as food reserves. Starch can be easily extracted with high purity, resulting in a white, tasteless and odorless powder. These good organoleptic properties make it an attractive resource for various applications [12]. Starch is composed of two main components, namely amylose and amylopectin, both components consist of D-glucopyranose connected by α-1,4 glycosidic bonds in the main chain and α-1,6 glycosidic bonds in the branch chains. The transformation of starch into film is usually carried out by a gelatinization process followed by solution casting or melt processing [6].



(a) (b)

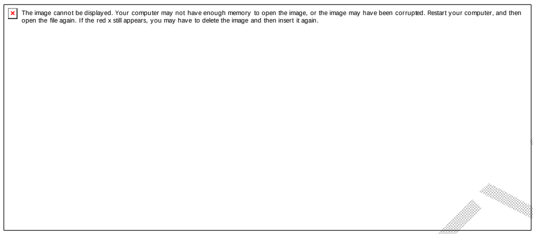
Figure1. Starch Ingredients Chemical Structure (a) Amylose (b) Amylopectin.
Source:Hassan et al.[13]

UNDER PEER REVIEW

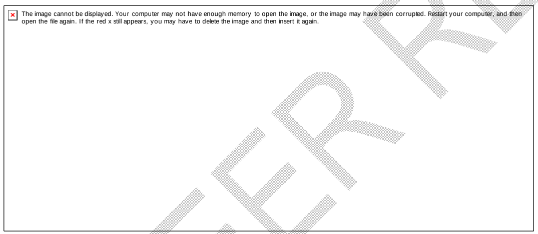
One of the starch extractions can be done on canna plants. As a plant with a fairly high starch content,The amylose content in canna starch ranges from 25-30% and amylopectin 70-75% with characteristic oval-shaped starch granules with sizes between 20-50 μm [14]. The use of starch in the manufacture of edible film produces a film that acts as a thickener and binder for edible film containing amylose and amylopectin [7].

2.2 Nanochitosan

Chitosan with a chemical structure of β-1,4-2 amino-2-dioxy-D-glucose is a multifunctional polymer containing three types of functional groups including amino acids, primary hydroxyl groups, and secondary hydroxyl groups so that chitosan has high chemical reactivity [15].



(a)



(b)

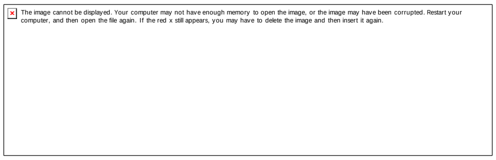
Figure 2. Chemical Structure of Chitin and Chitosan (a) Chitin (b) Chitosan
Source:Hassan et al.[13]

Chitosan is generally used as a thickener and stabilizer. Moreover, chitosan also develops gel and texture in a substance.Other properties of chitosan are as a film former, easily degraded, non-toxic, hydrophobic, and transparency in making edible film increases [7]. Modification of chitosan into nano form has been used as a filler additive in edible film formulations. Nanoparticles are solid particles with a size range of 10-1000 nm [16]. Nanomaterials with their smaller dimensions are able to attach to many biological molecules with greater efficiency. Nanoparticles provide increased mechanical, physical and barrier properties of edible film and can function as an encapsulation system for active components [11]. Modification of chitosan into a nano form is used as an additional filler in the edible film formula so that nanochitosan with a large surface area and positive charge from the amine group of particles can increase the antibacterial activity of the edible film. [17]

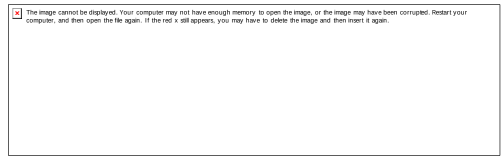
2.3 Oil and Acids

Fish oil Fish oil as one type of oil that can be added to edible film is a type of lipid extracted from fish. Fish oil itself is known to have various beneficial ingredients in it such as omega-3 content which has many benefits and is important for health, besides that it also contains essential fatty acids which the body does not produce naturally [18]. Apituley et al. [19] stated that the yield of oil from waste heads and bones of tuna was valued at 12.11 and 9.85% containing 25 types of fatty acids in the heads and 26 types of fatty acids in the bones consisting of SFA, MUFA and PUFA.

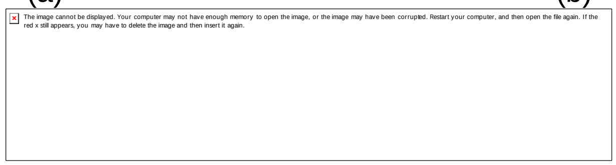
UNDER PEER REVIEW



(a)



(b)



(c)

Figure 3. Fish Oil Chemical Structure: (a) SFA, (b) MUFA, (c) PUFA
Source:Sartika[20]

Fatty acids are aliphatic compounds with a carboxyl group. Fatty acids are divided into saturated fatty acids and unsaturated fatty acids. Saturated fatty acids have only single bonds between the carbon atoms, while unsaturated fatty acids have at least one double bond between the carbon atoms. Unsaturated fatty acids are considered to have better nutritional value because they are more reactive and act as antioxidants in the body [21]. Fatty acids added to the edible film formulation can affect the physical properties of the film in certain variations, namely increasing the % elongation, but significantly reducing the stress value and water uptake value of the edible film [22].

The addition of lipid into edible film formulations can reduce the value of the film's water vapor permeability [12]. Lipid constituents as a good water vapor barrier can be used as an additive added to film containing polysaccharides or proteins to increase the hydrophobic and glossy properties of the resulting composite film [8]. Edible film with the addition of fish oil can complement the deficiencies of hydrocolloid properties which are easily soluble in water with their hydrophobic properties. The results of Yangilar's research [18] show that the process of coating edible film with chitosan enriched with fish oil can delay water loss in a product packaged by a film with ingredients containing fish oil.

3. PHYSICAL CHARACTERISTICS OF EDIBLE FILM

The characterization of the edible film serves as a determinant of the success of the resulting edible film production [23]. Good packaging is packaging that can control the permeability of water vapor and gas, easily decomposes in the soil, and is able to maintain the quality of food ingredients during the storage period. Characteristics of edible film according to Aguirre et al. [24] is the physical and mechanical properties includethickness, tensile strength, elongation percentage, solubility, water vapor transmission rate and water content. Nurinda et al. [25] also stated that edible film to be used as food packaging must meet the quality standards set by the Japanese Industrial Standard (1975). The following are edible film standards which can be seen in table 1.

Table 1. Standard Characteristics of Edible Film

Parameter	**Mark**
Thickness	max. 0.25mm
Tensile strength	Min. 0.39 MPa
Elongation	Min. 70%
Water Vapor Transmission Rate	max. 7g/m2/24 hours

Source: JIS (1975) in Santoso and Atma[26]

UNDER PEER REVIEW

3.1 Thickness

Thickness is an important parameter in measuring the characteristics of edible film that affect the use of film as packaging for food or edible products. The thickness value of the edible film will affect other characterization parameters such as the rate of water vapor transmission, tensile strength, and the percentage of elongation of the resulting edible film [26]. The smaller the thickness value of the edible film, the faster the water will penetrate the edible film, the higher the thickness value, the better the ability to hold water vapor. The thickness value must still be in accordance with the edible film thickness standard, which according to JIS (1975) the maximum edible film thickness value is 0.25 mm.Zahra et al.[27] stated that edible film that have a higher thickness will break easily compared to thin edible film when measuring tensile strength. The factors that can affect the thickness of the edible film include the area of the printed plate and the volume of the suspension, the constituent components, as well as the drying and addition of glycerol [28]

3.2 Water Vapor Transmission Rate

The water vapor transmission rate is a test carried out to find out how resistant the edible film made is in holding back the entry and exit of water vapor. The value of the transmission rate of water vapor must have the lowest value in order to be able to protect against external conditions, one of which is water vapor, the lower the value of the transmission rate of water vapor, the better the quality of the edible film [29]. The value of this water vapor transmission rate will also affect other characterization parameters such as tensile strength and elongation [28]. Factors that affect the value of the water vapor transmission rate include the structure of the material from the edible film constituent and the concentration of the added plasticizer [30].

3.3 Solubility

Solubility determines the ability of the edible film to dissolve in water and retain water. The percentage value of solubility of an edible film can be used as an indicator to measure water resistance, film integrity, and biodegradability of the edible film when used as a packaging material [31]. A high solubility value means that the edible film dissolves easily in water and is less able to hold water, so it is more suitable for application to ready-to-eat food products because the edible film dissolves easily when consumed. Edible film with low solubility are intended for edible film that are used in foods with high water content or the use of edible film that come in direct contact with water and function to protect food [1].Factors that affect the percentage of solubility of edible film include the source of the basic ingredients used in making edible film and added plasticizers [32].

4. EDIBLE FILM BIOCOMPOSITE WITH THE ADDITION OF FISH OIL

*Edible film*Biocomposite is a combination of natural polymers to form film. Santoso et al. [4] stated that biocomposite is an edible film formed from a combination of hydrocolloid and lipid biopolymers. The combination of the two polymers will complement each other by covering the deficiencies of each type of constituent. Listof edible polymers commonly used in making edible film can be seen in Figure 4.

UNDER PEER REVIEW

Figure 4. Types of Polymers*Edibles*
Source:Jeevahan and Chandrasekaran 2019 [8]

Polysaccharides are a component of the hydrocolloid group of edible film with various advantages.Muhammad et al. [32]mentioned that polysaccharides have strong hydrogen bonds that can bind functional additives such as color, flavor and micro-nutrients as well as a good oxygen barrier. Polysaccharides that can be used as ingredients for edible film include starch and chitosan[7]. The main objective of making composite film is to increase the value of the permeability of an edible film [33]. Of course, the combination of the two biopolymers between hydrocolloids and lipid on edible filmaffect the properties of the resulting edible film composite.The problem with this edible film composite lies in the homogenization of the hydrocolloid biopolymer with lipid, lipid components, and uniformity of dispersion distribution within the edible film framework [4]. Research on biocomposite edible film can be seen in Table 2.

Table 2. Biocomposite edible film with the addition of oil and acids

Title	**Reference**	**Results**
Development of Composite Edible Film Based on Corn Starch with the Addition of Palm Oil and Tween 20	Santoso et al. [4]	- The value of water content and water vapor transmission rate decreased with the addition of palm oil. - Tween 20 with a concentration of 1% can be an appropriate emulsifier in the formulation.
Effect of Fish Oil-Enriched Chitosan Edible Film on Microbiology, Chemical Composition and Sensory Properties of Cheese	Yangilar [18]	- The addition of 1% fish oil is the best concentration that has a significant effect on reducing the fungus
Characteristics of Edible Film Biocomposite from a Mixture of Chitosan and Pectin from Kepok Banana (Musa Acuminata) Peel Waste	Zuchrillah et al. [34]	- The transparency and color of chitosan are better than pectin which tends to be darker - Thickness is in good range according to JIS standard
Characterization of Biocomposite Edible Film Based	Debora [35]	- Reducing the water vapor transmission rate

UNDER PEER REVIEW

Title	Reference	Results
on Cassava Starch, Gelatin, and Nano Chitosan with the Addition of Oleic Acid		- Protect from light
Characteristics of Biocomposite Edible Film Based on Gelatin-Starch-Nano-Chitosan With the Addition of Lauric Acid	Nursabani [36]	- Lowers water vapor permeability - Has antimicrobial ability against food pathogenic bacteria

Based on the results of the above studies, the combination of ingredients and the addition of lipid into film formulations can reduce the value of the water vapor transmission rate and improve the physical characteristics of edible film. Hydrocolloid edible film constituents can protect products against air well but are not good enough in resisting the migration of water vapor. Lipid as constituents of other edible film are known for their good ability to protect the migration of water vapor which hydrocolloid types are unable to do. The combination of hydrocolloids and lipid is good to use because it can increase the advantages and reduce the weaknesses of each constituent [37].

5. CONCLUSION

Edible film is a thin layer of edible packaging which is made to protect food and aimed to be decomposed naturally. This may be an alternative to plastic packaging that is widely used today.Edible film components consist of hydrocolloids (polysaccharides, proteins), lipid, or a combination of these materials with or without the addition of plasticizers. Edible film made from starch and chitosan have weaknesses such as low barrier properties, brittleness and low tensile strength. Meanwhile, edible film with the addition of lipid such as fish oil can improve their physical properties.

REFERENCES

1. Rusli, A., Methusalach, Salengke, and MM Tahir. 2017. Characterization of Edible Carrageenan Film with Glycerol Plasticizers. Jphpi. 20(2): 219–229.
2. Pacheco, N., MG Naal-Ek, T. Ayora-Talavera, K. Shirai, A. Román-Guerrero, MF Fabela-Morón, and JC Cuevas-Bernardino. 2019. Effect of bio-chemical chitosan and gallic acid into rheology and physicochemical properties of ternary edible film. International Journal of Biological Macromolecules. 125:149–158.https://doi.org/10.1016/j.ijbiomac.2018.12.060
3. Prasetyo, A., DM Prasta, AD Arum, BY Islami, A. Lee, and S. Winarti. 2018. Edible Coating Characteristics of Air Potato Starch With the Addition of Different Plasticizers. Journal of Food Technology. 12 (1): 18 - 26.https://doi.org/10.33005/jtp.v12i1.1097
4. Santoso, B., Amilita, D., Priyanto, G., Hermanto, H., and S. Sugito. 2018. Development of Composite Edible Film Based on Corn Starch with the Addition of Palm Oil and Tween 20. Agritech. 38(2):119.https://doi.org/10.22146/agritech.30275
5. Menzel, C. 2014. Starch structures and their usefulness in the production of packaging materials.http://pub.epsilon.slu.se/11576/1/menzel_c_141103
6. Pelissari, FM, DC Ferreira, LB Louzada, F. Dos Santos, AC Corrêa, FKV Moreira, and LH Mattoso. 2018. Starch-based edible film and coatings: An eco-friendly alternative for food packaging. In Starches for Food Application: Chemical, Technological and Health Properties. Elsevier Inc.https://doi.org/10.1016/B978-0-12-809440-2.00010-1

UNDER PEER REVIEW

7. Mustapa, R., F. Restuhadi, and Efendi, R. 2017. Utilization of Chitosan as a Basic Material for Making Edible Film from Yellow Sweet Potato Starch. LET'S FAPERTA. 4(2): 1–5.https://jom.unri.ac.id/index.php/JOMFAPERTA/article/view/17104
8. Jeevahan, J., and M. Chandrasekaran. 2019. Nanoedible film for food packaging: a review. Journal of Materials Science. 54(19): 12290–12318.https://doi.org/10.1007/s10853-019-03742-y
9. Pacheco, N., MG Naal-Ek, T. Ayora-Talavera, K. Shirai, A. Román-Guerrero, MF Fabela-Morón, and JC Cuevas-Bernardino. 2019. Effect of bio-chemical chitosan and gallic acid into rheology and physicochemical properties of ternary edible film. International Journal of Biological Macromolecules. 125:149–158.https://doi.org/10.1016/j.ijbiomac.2018.12.060
10. Mandei, JH, and A. Muis. 2018. The Effect of Carrageenan Concentration, Type and Concentration of Lipid on the Production of Edible Coatings/Film and Their Applications to Tomatoes, Apples, and Nogat Cakes. Industrial Technology Research Journal. 10(1): 25–36.
11. Petkoska, AT, D. Davor, NM D Cunha, N. Naumvoski, AT Broach. 2021.Edible packaging: Sustainable solutions and novel trends in food packaging. Food Research International
12. Menzel, C. 2014. Starch structures and their usefulness in the production of packaging materials.http://pub.epsilon.slu.se/11576/1/menzel_c_141103
13. Hassan, B., SAS Chatha, AI Hussain, KM Zia, and N. Akhtar. 2018. Recent advances on polysaccharides, lipid and protein based edible film and coatings: A review. International Journal of Biological Macromolecules. 109:1095–1107.https://doi.org/10.1016/j.ijbiomac.2017.11.097
14. Muchsiri, M., and R. Martensyah. 2021. Edible: Research Journal of Food Technology Sciences (Jedb) UTILIZATION OF GANYONG STARCH AS A SUBSTITUTION OF TAPIOCA FLOUR IN THE PRODUCTION OF PEMPEK FISH SABUT (Channa striata) Utilization of Ganyong Starch as a Substitution Tapioca Flour for Snakehead Fish. 10 (1)
15. Rosida, DF, N. Hapsari, and R. Dewati. 2018. Edible Coatings and Film from Renewable Natural Material Biopolymers.
16. Mohanraj, VJ, and Y. Chen. 2007. Nanoparticles - A review. Tropical Journal of Pharmaceutical Research. 5(1): 561–573.https://doi.org/10.4314/tjpr.v5i1.14634
17. Rochima, E., E. Fiyanih, E. Afrianto, IM Joni, U. Subhan, and Panatarani, C. 2018. Effect of Adding Nanochitosan Suspension to Edible Coatings on Antibacterial Activity. Journal of Processing of Indonesian Fishery Products. 21(1):127.https://doi.org/10.17844/jphpi.v21i1.21461
18. Yangilar, F. 2016. 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. 36(3): 377–388.https://doi.org/10.5851/kosfa.2016.36.3.377
19. Apituley, DAN, RBD Sormin, and EEEM Nanlohy. 2020. Characteristics and Fatty Acid Profiles of Fish Oil from the Head and Bones of Tuna (Thunnus albacares). AGRITEKNO: Journal of Agricultural Technology. 9(1): 10–19.https://doi.org/10.30598/jagritekno.2020.9.1.10
20. Sartika, RAD 2008. Effect of Saturated, Unsaturated and Trans Fatty Acids on Health. Kesmas: National Public Health Journal,. 2(4):154.https://doi.org/10.21109/kesmas.v2i4.258
21. Utari, R. 2017. Asam Oleat. https://kupdf.net/
22. Wahyuningtyas, M., dan L. Atmaja. 2016. Pembuatan dan Karakterisasi Film Pati Kulit Ari Singkong/Kitosan dengan Plasticizer Asam Oleat. Indonesian Journal of Chemical Science. Vol. 5. No. 1.
23. Dwimayasanti R. Utilization of carrageenan as edible film. ocean. 2016;41(2):8-13.

UNDER PEER REVIEW

24. Aguirre-joya JA. DLZapata, OB Álvarezperez, C. Torres-león, D. E Nieto-oropeza, J. M Ventura-sobrevilla, M. A Aguilar. Chapter 1 - Basic and Applied Concepts of Edible Packaging for Foods. Food Packaging and Preservation. Elsevier Inc; 2017. DOI: 10.1016/B978-0-12- 811516- 9/00001-4
25. Nurindra AP, Alamsjah MA, Sudarno. Characteristics of edible film from lindur mangrove propagul starch (Bruguiera gymnorriza) with the Addition of Carboxymethyl Cellulose (CMC) as a plasticizer. J Fish Mar Sci. 2015;7(2):125- 32
26. Santoso, RA, and Y. Atma. 2020. Physical Properties of Edible Film from Pangasius catfish Bone Gelatin-Breadfruit Strach with Different Formulations. Indonesian Food Science & Technology Journal. 3(2): 42–47.https://doi.org/10.22437/ifstj.v3i2.9498
27. Zahra, H., Ratna, and AA Munawar. 2020. Production of Corn Starch-Based Edible Film Using Variations of Glycerol as a Plasticizer. Agricultural Student Scientific Journal. 5(1): 514–515.
28. Wijayani, KD, YS Darmanto, and E. Susanto. 2021. Characteristics of Edible Film from Different Fish Skin Gelatin. 3(1): 59–64
29. Agustina, S. and R. Eka. 2018.Surface Engineering of Chitosan Thin Film as the Basis for Development of Self Cleaning Technology. Journal of Learning and Teaching Physics. 1(2) : 2599 - 3143
30. Togas, C., S. Berhimpon, R. I Montolalu, HA Dien, and Mentang, F. 2017. Physical Characteristics of Carrageenan and Beeswax Composite Edible Film using the Nanoemulsion Process. Journal of Processing of Indonesian Fishery Products. 20, 468–477.
31. Cerqueira, MA, B. Souza, JA Teixeira, and AA Vicente. 2012. Effect of glycerol and corn oil on the physicochemical properties of polysaccharide film - A comparative study. Food Hydrocolloids. 27(1):175–184.https://doi.org/10.1016/j.foodhyd.2011.07.007
32. Mohamed, SAA, M. El-Sakhawy, and MAM El-Sakhawy. 2020. Polysaccharides, Proteins and Lipid -Based Natural Edible Film in Food Packaging: A Review. Carbohydrate Polymers. 238.https://doi.org/10.1016/j.carbpol.2020.116178
33. Nayik, GA, I. Majid, and V. Kumar. 2015. Characterization of Indian Honeys View project Sprouted onion View project Developments in Edible film and Coatings for the extension of Shelf Life of Fresh Fruits. American Journal of Nutrition and Food Science. 2(1): 16–20.https://doi.org/10.12966/ajnfs.CITATIONS
34. Zuchrillah, DR, L. Pudjiastuti, NF Puspita, A. Hamzah, AD Karisma, A. Surono, S. Altway, L. Ardiani, NA Rohmah, and EO Ningrum. 2020. Characteristics of Biocomposite Edible Film from a Mixture of Chitosan and Pectin from Kepok Banana (Musa Acuminata) Peel Waste. CHEESA: Chemical Engineering Research Articles. 3(1):33.https://doi.org/10.25273/cheesa.v3i1.6659
35. Debora, K., E. Rochima, and C. Panatarani. 2020. Effect of the Addition of Oleic Acid on Water Barrier Properties of Edible Film 1. Introduction: in Over Last Years, Plastics, As Non-Renewable Materials Packaging Has Caused a Serious Environmental Problem. There-Fore, It Is Necessary To Find Environment-F. Gsj. 8(2): 3832–3837.www.globalscientificjournal.com
36. Nursyabani, I., E. Rochima., AA Handaka., C. Pranatani and IM Joni. 2020. Lauric Acid on Edible Film: A Review. Global Science Journals, 8(2): 4005–4009.
37. Fahlevi, R., B. Santoso, and Priyanto, G. 2019. Characteristics of Canna Starch Functional Edible Film with the Addition of Gambir Filtrate (Uncaria gambir Roxb) and Kenikir Extract (Cosmos caudatus). Proceedings of the National Seminar on Suboptimal Land. 978–979.
UNDER PEER REVIEW