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Mechanical Properties and Water Vapour Transmission Rate of Sago Starch Based Edible Film with Palm Oil and Sorbitol as additives

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ABSTRACT--*Edible film is a thin layer made of materials that can be consumed and used to package food products. A good edible film has a high tensile strength and low water vapour transmission rate, so the edible film is able to protect food from mechanical interference and improve food durability. This research aimed to improve the mechanical properties and edible film water vapour transmission rate of sago starch based edible film using with palm oil and glycerol plasticizer. The addition of Gambier as an anti-microbial by adjusting the pH of the starch suspension using musk oranges. The process of synthesizing edible films consists of mixing all materials, forming gels, printing and drying. Observations made was included mechanical properties and edible film water vapour transmission rate. The results showed that the tensile strength tests obtained were in the range of 22.95 – 37.46 MPa, while the elongation percentages obtained were 313% - 484%. The tensile strength and elongation percentage obtained is above minimum value set by Japanese International Standard (JIS) for bioplastic (3.923 Mpa and 70%). The water vapour transmission rate obtained was 1.34 - 3.42 g/m^2/day. The lower value of water vapour transmission rate, the better edible film resists the water, hence the better quality of the edible film serves as food packaging.*

Keywords-- *Mechanical, Properties, Water Vapour Transmission, Rate, Sago Starch Based Edible Palm Oil Sorbitol additives*

I. INTRODUCTION

The use of packaging in daily life is very important to protect the food product so that the shelf life of the food product can be extended, as well as able to prevent microbial contamination from the surrounding environment. However, the use of synthetic packaging is still widely practiced and it has a negative impact on the environment and health. Therefore, to reduce the negative impact of synthetic packaging on the environment and health, it is necessary to have a type of packaging that can be degraded naturally (Gennandios and Waller in Estiningtyas, 2010). One alternative packaging that can be synthesized is edible film.

According to Darini et al. (2009), edible film is an alternative to replace plastic packaging because it is biodegradable as well as acting as a barrier to control water vapour transfer, oxygen uptake, and lipid transfer.

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Edible film can also be used to coat products that function as protectors from mechanical damage and are safe for consumption. The development of edible films as food packaging materials that are safe for consumption by humans continues to increase from year to year.

The addition of antimicrobial material to the edible film will increase the shelf life and stability of food because the barrier properties of the film layer are strengthened by the active component of antimicrobials. Natural antibacterial compounds can be potentially added to the edible film formulations are Gambier. According to Pambayun et al. (2001) Gambier extract containing katekin compounds with levels of 67.55-72.02 %. Research from Santoso (2011) and Santoso et al. (2014) regarding the improvement of edible film characteristics especially antibacterial properties, it is necessary to adjust the pH of edible film suspension using musk orange. Musk orange juice has a pH range of 2.5 to 3.8. pH is very important because it has an important role which is to maintain the stability of the katekin compounds in Gambier.

Edible film is a food packaging material that is shaped like a plastic made from biopolymer and is safe for human consumption. Edible film polymer materials consist of three groups, namely hydrocolloids, lipids, and composites. Hydrocolloid has advantages, especially the sticking ability to packaged food, but has a weakness against water vapour transmission. Examples of hydrocolloid polymeric materials are starch, pectin and protein. Lipids have the advantage of retaining the rate of water vapour transmission, but are rigid and easily cracked. Lipid groups are often used such as beeswax, palmitic acid, and palm oil. Lipids have the advantage of being difficult to penetrate by moisture, but are rigid or less elastic. While the composite is a combination of hydrocolloids with lipids.

Starch is one of the polymers whose characteristics resemble plastic and one type of polysaccharide that is abundant in nature, biodegradable, easily obtained, and inexpensive. Sago starch has advantages as a basic material to produce biodegradable films because it is easily gelatinized at low temperatures, has a high viscosity and easy to print (Anggraeni, 2011). Sago starch has the potential to be developed as a base for edible films.

Starch and pectin films have high elasticity, but are fragile so they break easily (Abdorreza et al., 2011) and are hydrophilic (very sensitive to water). According to Kester and Fennema (1986), Hernandez (1994); to improve the weaknesses of edible film, lipids and plasticizers can be added in the film formulation. According to Tanaka (Santoso, 2017) the addition of unsaturated fatty acids to the solution has a significant effect to reduce water vapour transmission rate of edible film. Manab (Santoso, 2017) reports that the addition of palm oil by 10% can reduce the rate of water vapour transmission. The addition of plasticizer to the edible film is important to overcome the fragile property of the film due to extensive intermolecular strength.

This research to examine the effect of adding Gambier and glycerol plasticizers to improve mechanical properties of edible film and the effect of adding palm oil to reduce water vapour transmission rate of edible film. The addition of Gambier as an anti-microbial by adjusting the pH of the starch suspension using musk oranges juice. The resulting edible packaging is expected to achieve good characteristics, especially in the mechanical properties and water vapour transmission rate as well as anti-microbial properties to improve the durability of food during storage.

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II. METHODOLOGY

Sago starch (local based), Palm oil, Sorbitol plasticizer, musk orange and Gambier, supplied by Merck Germany were used without any further pre-treatment. Sago 50 mg was diluted in 300 ml water and heated to 70ºC while stirring at 300 rpm to achieve the gelatinisation temperature and forming gel. Sorbitol plasticizer 9 ml was added to the gel. Gambier and palm oil of three variations of 4.5 and 9 gram/ml added to the mixture as additive and stir until homogeny. To maintain the suspension pH of 3 and 4, musk orange was added. The suspension was printed on the glass casting with diameter 20 × 20 cm and levelled up at the surface. Furthermore, it was heated in the oven to dry at 70-80oC for 24 hours. Dried edible film was put in desiccator for 24 hours and ready for analysis. Analysis performing was tensile and elongation test (mechanical properties), and water vapour transmission rate.

III. RESULT AND DISCUSSION

Mechanical Properties

Tensile strength is the measurement of the force required to pull something to the point where it breaks. The tensile strength for the edible film was performed by using Universal Testing Machines Electronic System based on the standard ASTM D638, 1991. The tensile strength for each sample is presented in Table 1.

Table 1: Mechanical Properties of Edible Film

Sampel	**Gambier (gr)**	**Palm Oil (ml)**	**Tensile Strenght (Mpa)**	**Elongation (%)**
Edible film - 1	4.5	4.5	22.947	313
Edible film - 2	4.5	9	33.146	440
Edible film - 3	9	4.5	37.461	484
Edible film - 4	9	9	30.792	354

Tensile strength is the maximum tensile force that can be resisted by a bioplastic until broken. Low tensile strength indicates the relevant bioplastic cannot be used as packaging material, because it is easily broken. The test is carried out by giving a load to the bioplastic and then the bioplastic is pulled until it breaks. This measurement is to determine the magnitude of the force required to achieve maximum pull in each area of the film. Tensile strength depends on the concentration and type of edible film mixture, especially the structural cohesion. Structural cohesion is the ability of polymers to determine the strength of molecular chains bonding between polymer chains.

Table 1 showed, the highest tensile test obtained was 37.461 Mpa for edible film- 3. Santoso (2011) explained that the use of surfactants with the right concentration and type will affect the homogeneity of the film suspension formed. Homogeneous film suspension will produce a tight, solid and flat edible film, furthermore affected the mechanical properties of the edible film. Palm oil contains liquid unsaturated fatty acids at room temperature. Unsaturated fatty acids have good mobility of their double bonds, hence spread evenly in the edible films matrix. It is not affected the tensile strength, but decreasing the transmission of water vapor rate. According to *Japanese International Standard* (JIS) (1975), edible film tensile strength minimum is 3.923 Mpa and the result obtained from this research showed the value is above the minimum standard.

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For elongation, the highest percentage of elongation obtained was 484 % for edible film - 3. Elongation is the maximum length change before the film breaks. Elongation percentage represents the film's ability to stretch maximally. From Table 1 can be seen, adding gambier extract concentration at different concentration has affected the elongation value. Higher concentration of gambier extract added has contributed to the increasing of the elongation value. This is due to the catechin compound in gambier extract that contained hydroxyl group (OH). OH group can bind water, so the higher the concentration of gambier extract, the more OH groups that can bind water in the matrix (Pambayun, 2008). The amount of water bound in the matrix affects the increase in elasticity. Rodriguez et al. (2006) explained that glycerol which contains a lot of OH groups in the edible matrix system can increase the rate of water vapor transmission and the elongation percentage.

The result showed, higher concentration of palm oil contributed to the decreasing of elongation percentage value. Palm oil contains unsaturated fatty acids which are hydrophobic and liquid at room temperature. Unsaturated fatty acids can regulate fatty acids in the matrix so that they are even and dense which causes a decreased level of elasticity.

According to Martin-Polo et al. (1992), the use of liquid lipids in film formulations can form a denser edible film structure. According to the Japanese International Standard (JIS) (1975) the elongation percentage value of edible film is minimum 70%. While the results of edible films obtained in this study obtained is above the value of JIS.

Water Vapour Transmission Rate (WVTR)

According to Agustin, et al. (2016), the Water Vapor Transmission Rate (WVTR) test is one of the tests that states the amount of water vapor can be passed through a bioplastic film layer. Measurement of the water vapor transmission rate of a material is an important factor in assessing the permeability of edible films to water vapor. This test is carried out using the desiccant method of the material being tested. The WVTR results for each sample with different volume of oil palm weight can be seen in Table 2 below.

Table 2: Water Vapour Transmission Rate (WVTR)

No sampel	**Gambier (gr)**	**Palm Oil (ml)**	**pH**	**WVTR (g.m^{-2}.day^{-1})**
Edible film - 1	4.5	4.5	3	3.28
Edible film - 2	4.5	9	3	1.34
Edible film - 3	9	4.5	3	2.95
Edible film - 4	9	9	3	2.76
Edible film - 5	4.5	4.5	4	3.42
Edible film - 6	4.5	9	4	2.63
Edible film - 7	9	4.5	4	2.40
Edible film - 8	9	9	4	2.69

Edible film packaging is expected to protect food ingredients by maintaining oxygen and moisture outside the packaging. The bioplastic permeability to gas and water vapor is able to protect the packaged product by keeping oxygen and water vapor outside the package. However, in reality edible film is not absolutely able to hold the

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water vapor, hence in this study it is expected that the addition of palm oil to sago-based edible film can reduce the rate of water vapor transmission.

The resulting water vapor transmission rate meets the Japan International Standard (JIS) (1975) which is a maximum of 10 $g.m^{-2}.day^{-1}$. The lowest water vapor transmission rate is obtained for Edible film - 2. This happens because the formation of complex matrix bonds between gambier-glycerol-palm oil. Unsaturated fatty acids in palm oil will regulate the fatty acids in the matrix structure more evenly and densely, if the concentration of palm oil is higher consequently more unsaturated fatty acids in the matrix structure are spread evenly. Unsaturated fatty acids are hydrophobic or non-polar, so the higher the concentration of unsaturated fatty acids in the matrix, the more difficult water vapor can penetrate. The concentration of fatty acids has a great effect on the inhibitory properties of fatty acids. (Garcia, 2000).

The lowest water vapor transmission rate in this study was 3.43 $g.m^{-2}$ $days^{-1}$ and the best was 1.34 $g.m^{-2}$ $days^{-1}$ and lower when compared with the results of the study conducted by Santoso et al. (2014) which is 4.18 $g.m^{-2}.day^{-1}$. The lower the value of water vapor transmission rate, the better resistance of edible film to water vapor

IV. CONCLUSION

From the discussion above, it can be concluded that glycerol and Gambier plasticizers improve the mechanical properties of edible film and the result showed that tensile strength and percent elongation obtained was above the Japan International Standard (JIS) (1975). Palm oil also affected the water vapor transmission rate of edible film. The value of the water vapor transmission rate obtained was below the JIS value. Hence, it can be concluded that mechanical properties and water vapor transmission rate was improved with additional of glycerol, palm oil and Gambier.

REFERENCES

1. Abdorreza, M.N., Cheng, I.H. dan Karim, A.A.. Effect of plasticizers on thermal properties and heat sealability of sago starch films. Food Hydrocolloids 25: 56-60. 2011
2. Amaliya, dkk. Karakterisasi edible film daripati jagung dengan penambahan filtrat kunyit putih sebagai antibakteri. J. Pangan dan Agroindustri Vol.2 No.3. 2014
3. Bourtoom, T. Effect of Some Process Parameters on The Properties of Edible Film Prepared From Starch. Department of Material Product Technology. Songkhala. 2007.
4. Estiningtyas, H.R. Aplikasi Edible Film Maizena dengan Penambahan Ekstrak Jahe sebagai Antioksidan Alami pada Coating Sosis Sapi. Skripsi. Hal 6-9. 2010
5. Guilbert, S. And B. Biquet. Edible films and coatings. In G. Bureau and J.L multon . food packaging. Vol 1 VCH Publisher. New york. 1990
6. Haryanto, B dan Pangloli. 1992. Potensi dan Pemanfaatan Sagu. Yogyakarta : Kanisius. 1992
7. Johan, Alfredo, dkk. Pengaruh jenis dan konsentrasi plasticizer terhadap sifat fisik edible film kolang kaling (arenga pinnata). J. Pangan dan Agroindustri Vol.5 No.1:13-25. 2017.
8. Krochta, J. M. Edible Coating and Film to Improve Food Quality. Lancester: Tehnomic Publisher. Co. Inc.1992

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9. Murdinah, dkk. Karakteristik edible film dari komposit alginat, gluten dan lilin lebah (beeswax). J. Pascapanen dan Bioteknologi Kelautan dan Perikanan Vol. 2 No. 1. 2007.
10. Pambayun, R., Hasmeda, M., Saputra, D. dan Suhel. Peningkatan Produksi dan Perbaikan Kualitas Gambir Toman, Musi Banyu Asin. Laporan Kegiatan Program Vucer Multi Years, Kerjasama DITBINLITABMAS DIKTI melalui UNSRI dengan Pemda Musi Banyuasin, Sumatera Selatan. 2001.
11. Pambayun, R., Gardjito, M., Sudarmadji, S. dan Kuswanto, K.R. Kandungan Fenol dan Sifat Antibakteri dari Berbagai Jenis Ekstrak Produk Gambir (Uncaria gambir Roxb). Majalah Farmasi Indonesia 18 (3): 141-146. 2007
12. Pambayun, R., Gardjito, M., Sudarmadji, S. dan Kuswanto, K.R. Kandungan ekstrak daun gambirdan aktivitas antibakterinya. Agritech 27: 89-94, 2007
13. Pambayun, R., Pangawikan, A.D., Widowati, T.W., Hamzah, B., Santoso, U., Yudono, B. dan Gardjito, M. Utility of gambir catechin for tofu preservation. The 14th World Food Congress, International Union Food Science and Technology (IuFOST), Sanghai, China. 2008.
14. Santoso, B. Integrasi Pati Termodifikasi, Surfaktan, Protein, dan Ekstrak Tanaman Gambir pada Pembuatan Edible Film. Disertasi Program Doktor Ilmu-ilmu Pertanian Program Pascasarjana Universitas Sriwijaya. 2011.
15. Santoso, B., Pratama, F., Basuni, H. dan Pambayun, R. Pengembangan edible film dengan menggunakan pati ganyong termodifikasi ikatan silang. Jurnal Teknologi dan Industri Pangan 22(2): 105-109. 2011
16. Santoso, budi, dkk. Perbaikan sifat Fisik, Kimia, dan Antibakteri Edible Film Berbasis Pati Ganyong. J. Teknologi Hasil Pertanian. Vol. 36, No. 4. 2016
17. Vensia Novi M dan Joni Kusnadi. Antibakteri dari Ekstrak Kasar Daun Gambir (Uncaria Gambir Var Cubadak) Metode Microwave-Assisted Extraction Terhadap Bakteri Patogen. J. Pangan dan Agroindustri Vol. 3 No 1. 2015
18. Yulianti, rahmi dan Erliana Ginting. Perbedaan Katakteristik Fisik Edible Film dari Umbi-Umbian yang Dibuat dengan Penambahan Plasticizer. Jurnal Penelitian Pertanian Tanaman pangan., Vol.31., No.2.2012.

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