Food Research 8 (6) : 244 - 249 (December 2024)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

Characteristics of composite edible films from sago starch and gelatin

*Picauly, P., Breemer, R., Rupilu, R., Polnaya, F.J. and Ega, L.

Department of Agricultural Technology, Faculty of Agriculture, University of Pattimura, Poka, 97233, Ambon, Indonesia

Article history:
Received: 11 July 2023
Received in revised form: 23 September 2023
Accepted: 25 September 2024
Available Online: 9 December 2024

Keywords:
Sago starch,
Gelatin,
Edible film

DOI:
https://doi.org/10.26656/fr.2017.8(6).225

Abstract

The utilization of sago starch as a raw material for edible films is still under development. The properties of films produced from sago starch are not yet optimal, necessitating research to enhance their quality. The use of a composite material consisting of tuni sago starch and gelatin is expected to improve the characteristics of these edible films. This research aimed to determine the characteristics of edible film composites made from sago starch and gelatin. The research employed an experimental approach with a completely randomized design, varying the ratio of tuni sago starch to gelatin across five treatment levels (3:0; 2.75:0.25; 2.5:0.5; 2.25:0.75; 2:1 (g/g)). The results revealed that the composite treatments of sago starch and gelatin produced films with thickness values ranging from 0.060 to 0.86 mm, tensile strength ranging from 0.62 to 9.76 MPa, elongation ranging from 0.23 to 6.44%, solubility ranging from 28.96 to 59.01%, and water vapor transmission rates ranging from 11.41 to 20.03 g/m^2.h. It was observed that higher concentrations of gelatin in the edible films led to increased thickness, tensile strength, elongation, solubility, and water vapor transmission rates.

1. Introduction

The food industry has a growing interest in developing edible films for coatings and packaging materials. This trend arises from the increasing awareness of the need for biodegradable packaging materials as alternatives to non-degradable plastics. Edible films are thin, plastic-like sheets that are biodegradable and derived from renewable sources, including animal and vegetable materials. Adopting edible films offers a promising solution to mitigate environmental pollution caused by plastic waste.

Edible films consist of three primary categories of components: hydrocolloids (proteins and polysaccharides), lipids, and composites (combinations of various materials). Commonly used proteins for edible films include gelatin, whey, casein, soy, wheat, and corn (Al-Awwaly *et al.*, 2010). Hydrocolloids encompass protein compounds, cellulose derivatives, alginate, starch, pectin, and other polysaccharides (Skurtys *et al.,* 2010). Lipids typically used include waxes, acylglycerols, and fatty acids.

Starch is a foundational material for producing edible films due to its relatively lower cost than proteins and lipids and its widespread availability, edibility, and thermoplastic properties (Mali *et al.,* 2005). Commonly used starch sources for edible films include breadfruit starch (Setiani *et al*., 2013), taro starch (Warkoyo *et al.,* 2014), arrowroot starch (Syarifuddin and Yunianta, 2015), sago starch (Polnaya *et al*., 2006; Layuk *et al*., 2019) and cassava starch (Rosida *et al*., 2018; Rumyaan *et al*., 2022). A crucial property of starch's suitability for edible films is a high amylose content (approximately 30%) (Bae *et al.,* 2008).

Previous studies have indicated that native sago starch typically contains amylose content ranging from 27 to 33% (Polnaya *et al.,* 2012). These findings suggest that starch can produce edible films (Wattimena *et al*., 2016; Karouw *et al.,* 2017). However, pure starch-based edible films have low strength and brittleness despite their excellent oxygen barrier properties due to their compact structure (Mali *et al.,* 2005). To address these limitations, it is possible to enhance starch-based edible films by incorporating suitable composites, blending sago starch with other ingredients, or modifying it. Examples of blended materials include pectin (Polnaya *et al.,* 2019), carrageenan (Ismawanti *et al.,* 2020), and gelatin (Channa *et al.,* 2022).

Gelatin is a notable material for forming edible

*Corresponding author.
Email: *priscilliapicauly@gmail.com*

eISSN: 2550-2166 /
Published by Rynnye Lyan Resources

films, known for its transparency, strength, flexibility, and ability to impede oxygen and carbon dioxide transfer. Gelatin can be derived from collagen-rich sources such as fish skin and animal bones (Badii *et al*., 2006). The utilization of gelatin in edible film production results in improved appearance, increased solubility, and enhanced elasticity (Hasnelly *et al.,* 2015; Channa *et al*., 2022). The objective of this study was to determine the characteristics of edible film composites made from tuni sago starch and gelatin.

2. Materials and methods

2.1 Materials

This research used materials to produce an edible film, including native tuni sago starch and commercial gelatin. Native tuni sago starch was sourced from local farmers in Ambon Island, Maluku, and underwent laboratory cleaning procedures. The chemicals employed included sodium azide, chloride, and glycerol (Merck, Germany). The equipment used for both edible film preparation and analysis encompassed a 25 × 17 cm mold plate, a hot air oven (Memmert, Germany), an IP-65 micrometer (Mitutoyo, Japan), a Universal Testing Machine (UTM) (Zwick Z.05), and a vapor transmission rate cup.

2.2 Research procedure

The procedure for creating the edible film was based on the method outlined by Meneguin *et al.* (2014) with some modifications. A composite mixture of sago starch and gelatin (at ratios of 3:0; 2.75:0.25; 2.50:0.5; 2.25:0.75; 2:1) (w/v) was dispersed in 80 mL of distilled water. This dispersion was stirred for 30 mins at room temperature and then heated on a hot plate at 70°C for 15 mins while continuously agitated using a magnetic stirrer. After 15 mins, 1% glycerol and additional distilled water were added to the sago starch and gelatin mixture until the total volume reached 100 mL. Heating was continued with stirring at 70°C for another 15 mins. The solution was poured onto a mold plate measuring 25 × 17 cm after this process. The film solution was dried in an oven at 40°C for 14 hrs. Before analysis, the film was stored in a container maintained at 50% relative humidity and room temperature.

2.3 Variable of observation

Various variables were observed, including film thickness, which was measured using an IP-65 micrometer, film solubility (Wattimena *et al.*, 2016), elongation, and tensile strength, which were determined using a Universal Testing Machine (Zwick Z.05 Texture Analyzer) (Wattimena *et al.*, 2016), and the water vapor transmission rate, which was assessed using the gravimetric method (Wattimena *et al*., 2016).

2.4 Data analysis

The data obtained were subjected to statistical analysis employing a completely randomized design with three replicates. In the event of significant or highly significant effects, further analysis was conducted using the Tukey test (α = 0.05). Data analysis was carried out using the Minitab 19 software program.

3. Results and discussion

3.1 Chemical component of tuni sago starch

The chemical composition of the tuni sago starch produced in this research is presented in Table 1. Tuni sago starch exhibited a moisture content of 11.08%, ash content of 0.086%, and amylose content of 38.12%. In contrast, Polnaya *et al.* (2008) reported a composition for tuni sago starch with a moisture content of 12.96%, ash content of 0.133%, and amylose content of 37.34%.

Table 1. Chemical component of tuni sago starch.

Component	Tuni sago starch
Water content	12.08%
Ash content	0.09%
Amylose	38.12%

Variations in the chemical composition of sago starch can be attributed to the age of the sago plant. Older plants tend to have lower moisture content but a higher amylose ratio. Research by Uthumporn *et al.* (2014) demonstrated that different ages of sago plants result in distinct chemical compositions in terms of water content, ash content, and amylose. Proper nutrient intake can also influence these characteristics, as nutrients available in the macro and micro soil affect the amylose-to-amylopectin ratio in starch. Moreover, mineral content in starch can be influenced by the soil's mineral composition, subsequently affecting starch characteristics. As Singh *et al*. (2004) noted, amylose content varies depending on the biological source and is influenced by climatic conditions and soil type during plant growth. Additionally, humidity and temperature variations can impact plant composition, while soil type affects nutrient availability.

3.2 Mechanical characteristics of edible film

3.2.1Thickness

The thickness of the edible film resulting from the combination of sago tuni starch and gelatin ranged from 0.06 mm to 0.086 mm (Table 2). Notably, the treatment with a sago tuni starch-to-gelatin ratio of 2:1 (w/v) produced the thickest edible film, averaging 0.086 mm. These results align with previous findings by Fakhri *et al*. (2012), which reported optimal edible film thickness

https://doi.org/10.26656/fr.2017.8(6).225

values ranging from 0.058 mm to 0.075 mm.

The increase in edible film thickness with higher gelatin concentrations is attributed to gelatin's role as a hydrocolloid component, influencing viscosity and thickening the solution, thus augmenting the film's thickness. Moreover, a higher concentration of constituent polymer and total dissolved solids can enhance film formation. This is in accordance with the observations of Nugroho *et al*. (2013), who asserted that an increased amount of solids in the solution results in a more significant proportion of polymers forming the edible film matrix. Greater thickness values result in stiffer and more robust edible films, providing enhanced protection against external influences (Jacoeb *et al*., 2014).

3.2.2 Tensile strength

Analysis of the tensile strength variable for edible films composed of a mixture of sago tuni starch and gelatin yielded values ranging from 0.62 to 11.9 MPa for all treatments (Table 2). The treatment with a sago tuni starch-to-gelatin ratio of 2:1 (w/v) exhibited the highest tensile strength value, reaching 11.9 MPa. In contrast, the lowest value was recorded for the treatment with a ratio of 2.5:0.5 (w/v). Krochta and Johnston (1997) recommended a 10-100 MPa tensile strength range for standard edible films. Edible films with tensile strength values falling between 1-10 MPa are classified as marginal and can potentially be improved (Han and Gennadios, 2005). Thus, edible films made from sago starch and gelatin displayed good tensile strength, particularly in the treatment with a sago starch-to-gelatin concentration of 2:1.

Table 2. Effect of sago starch composite concentration ratio on mechanical characteristics of edible film.

Sago starch: Gelatin (g/g)	Thickness (mm)	TS (MPa)	Elongation (%)
3:0	0.076^{ab}	2.31^{c}	0.88^{c}
2.75:0.25	0.064^{b}	0.81^{cd}	0.24^{c}
2.5:0.5	0.060^{b}	0.62^{d}	0.23^{c}
2.25:0.75	0.075^{ab}	9.76^{b}	3.44^{b}
2:1	0.086^{a}	11.9^{a}	6.44^{a}

Values with different superscripts within the same column are statistically significantly different based on Tukey test (α = 0.05).

The results of this study align with the research conducted by Fakhri *et al.* (2012), who found that high tensile strength in edible films was influenced by a higher gelatin content. This was due to the protein content in collagen present in gelatin and the woven network structure, both of which enhance tensile strength. According to Warkoyo *et al.* (2014), gelatin protein functions as a structural element, forming a triple helix that further reinforces the tensile strength of edible films. Edible films made from gelatin exhibit favorable mechanical properties owing to gelatin's flexibility and elasticity. Increased tensile strength also leads to better resistance against stretching and pressure, making higher tensile strength desirable.

3.2.3 Elongation

The analysis revealed that the elongation values of edible films produced from various tuni sago starch and gelatin treatments ranged from 0.23% to 6.44% (Table 2). The treatment with a sago starch-to-gelatin ratio of 2:1 (w/v) exhibited the highest average elongation value at 6.44%, while the lowest value was recorded for the 2.5:0.5 (w/v) ratio treatment.

3.3 Physical characteristics of edible film

Data presented in Table 3 reveals that the solubility of edible films made from tuni sago starch and gelatin across all treatments ranged from 28.96% to 59.01%. The highest solubility value was observed in the treatment with a sago starch-to-gelatin ratio of 2:1, reaching 59.01%, while the lowest solubility value of 28.96% was obtained in the 2.5:0.5 ratio treatment. Notably, the best solubility value of edible film produced with a 2:1 ratio of sago and gelatin exceeded the findings of Wattimena *et al*. (2016), who created edible films using a mixture of sago starch and glycerol with solubility values ranging from 33.44% to 42.43%.

Table 3. Effect of concentration ratio treatment of sago starch-gelatin composite on physical characteristics of edible film.

Sago starch : Gelatin (g/g)	Solubility (%)
3:0	45.32^{b}
2.75:0.25	38.78^{b}
2.5:0.5	28.96^{c}
2.25:0.75	47.79^{b}
2:1	59.01^{a}

Values with different superscripts within the same column are statistically significantly different based on Tukey test (α = 0.05).

Overall, the study results highlight the crucial role of gelatin in enhancing the solubility of edible films. This observation aligns with similar studies, where incorporating gelatin with various starch types in edible film production led to increased solubility relative to the gelatin concentration (Fakhri *et al*., 2012). This increase in solubility may be attributed to hydrophilic components, with gelatin being one such component. Materials with higher hydrophilic properties, such as gelatin, tend to exhibit more excellent solubility, whereas materials with higher hydrophobic properties display lower solubility. Bourtoom (2008), noted that increased

https://doi.org/10.26656/fr.2017.8(6).225

solubility in edible films with higher plasticizer concentrations is due to the hydrophilic nature of the plasticizer, making it more soluble upon consumption (Pitak and Rakshit, 2011). High solubility also has implications for the biodegradability of edible films. For instance, low solubility is a critical requirement for edible films used in food encapsulation, as they typically encounter moisture and act as protective barriers for food products (Atef *et al.*, 2015; Singh *et al.*, 2015).

Furthermore, an increase in the quantity of sago starch without gelatin leads to higher solubility in the edible film. This is primarily attributed to the weaker hydroxyl group bonds in starch, which result in increased film solubility. The solubility of starch-based edible films is influenced by factors such as the hydroxyl group bonds in starch, the sago starch blending process, gelatinization temperature, and starch amylose content. Amylose, a soluble starch fraction, is released from granules when gelatinized. Therefore, higher solubility is associated with a greater release of the amylose fraction during gelatinization.

3.3.1 Barrier characteristics of edible film

The analysis of the water vapor transmission rate (WVTR) of the edible film composed of tuni sago starch and gelatin revealed values ranging from 11.41 to 20.03 g/m².h (Table 4). The treatment with a composite concentration ratio of sago starch and gelatin at 2:1 demonstrated the highest average WVTR value of 20.03 g/m².h.

Table 4. Effect of concentration ratio treatment of sago starch-gelatin composite on physical and barrier characteristics of

Sago starch : Gelatin (g/g)	WVTR (g/m^2.h)
3:0	13.63^{bc}
2.75:0.25	12.47^{c}
2.5:0.5	11.41^{c}
2.25:0.75	15.37^{b}
2:1	20.03^{a}

Values with different superscripts within the same column are statistically significantly different based on Tukey test (α = 0.05).

As noted by Cho *et al*. (2004), the elevated transmission rate value is associated with both the high protein content in gelatin-based films and the thickness of the film. Films with greater protein content and thickness can absorb more moisture from the surrounding environment. Edible films with a higher protein content may exhibit increased hygroscopicity compared to those with a lower protein content.

Compared to several similar studies, the WVTR value generated by edible film produced from a 2:1 ratio of sago starch and gelatin is notably superior, measuring 20.03 g/m²h. Research by Hasdar *et al.* (2011), where edible films were fabricated from a blend of chicken feet gelatin and soy protein isolate, resulted in WVTR values ranging from only 0.00366 to 0.00176 g/m².h. Furthermore, in a study by Julianto *et al.* (2011) involving gelatin and sorbitol, the WVTR ranged from 8.0503 to 7.2117 g/m².h. This disparity can be attributed to the gelatin's inherent water-absorbing properties, which affected the quality of the edible film. The WVTR indicates an edible film's ability to withstand water vapor from the product, with lower values indicating superior film quality (Amaliya and Putri, 2014). Water vapor migration primarily occurs within the hydrophilic portion of the film, and thus, the ratio between the film components' hydrophilic and hydrophobic segments impacts the WVTR. Consequently, a higher degree of hydrophobicity in the film results in an increased WVTR.

4. Conclusion

Based on the research findings, it can be concluded that the treatment of sago starch for edible film production in combination with gelatin (at various ratios: 3:0; 2.75:0.25; 2.5:0.5; 2.25:0.75; 2:1) significantly influenced the mechanical, physical, and barrier properties of the resulting edible films. A higher concentration of gelatin in the edible film led to increased values for thickness, tensile strength, elongation, solubility, and water vapor transmission rate.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

The authors would like to thank Rahmat Teguh (Faculty of Agricultural Technology, Gadjah Mada University, Indonesia) for performing tensile strength and elongation measurements.

References

Amaliya, R.R. and Putri, W.D.R. (2014). Characterization edible Film of corn starch with the addition of white saffron filtrate as antibacterial. *Pangan dan Agroindustri*, 2(3), 43-53. [In Bahasa Indonesia].

Al-Awwaly, K.U., Manab, A. and Wahyuni, E. (2010). Production of whey protein edible film: The study of protein and glycerol ratio on physical and chemical properties. *Jurnal Ilmu dan Teknologi Hasil Ternak,* 5(1), 45-56. [In Bahasa Indonesia].

Atef, M., Rezaei, M. and Behrooz, R. (2015).

https://doi.org/10.26656/fr.2017.8(6).225

Characterization of physical, mechanical, and antibacterial properties of agar-cellulose bionanocomposite films incorporated with savory essential oil. *Food Hydrocolloids*, 45, 150-157. https://doi.org/10.1016/j.foodhyd.2014.09.037

Badii, F. and Howell, N.K. (2006). Fish Gelatin: Structure, gelling properties and interaction with egg albumen properties. *Food Hydrocolloids,* 20(5), 630-640. https://doi.org/10.1016/j.foodhyd.2005.06.006

Bae, H.J., Cha, D.S., Whiteside, W.S. and Park, H.J. (2008). Film and pharmaceutical hard capsule formation properties of mungbean, water chestnut, and sweet potato starches. *Food Chemistry*, 106(1), 96-105. https://doi.org/10.1016/j.foodchem.2007.05.070

Bourtoom, T. (2008). Edible films and coatings: characteristics and properties. *International Food Research Journal*, 15(3), 237-248.

Channa, I.A., Ashfaq, J., Siddiqui, M.A., Chandio, A.D., Shar, M.A. and Alhazaa, A. (2022). Multi-shaded edible films based on gelatin and starch for the packaging applications. *Polymers*, 14(22), 5020. https://doi.org/10.3390/polym14225020

Cho, S.M., Kwak, K.S., Park, D.C., Gu, Y.S., Ji, C.I., Jang, D.H., Lee, Y.B. and Kim, S.B. (2004). Processing optimization and functional properties of gelatin from shark (*Isurus oxyrinchus*) cartilage. *Food Hydrocolloid*, 18(4), 573-579. https://doi.org/10.1016/j.foodhyd.2003.10.001

Fakhri, F.M., Martelli, S.M., Bertan, L.C., Yamashita, F., Mei, L.H.I. and Queiroz, F.P.C. (2012). Edible films made from blends of manioc starch and gelatin – Influence of different types of plasticizer and different levels of macromolecules on their properties. *Food Science and Technology*, 49(1), 149-154. https://doi.org/10.1016/j.lwt.2012.04.017

Han, J.H. and Gennadios, A. (2005). Edible Films and Coatings: A Review. In Han, J.H. (Ed.) Innovations in Food Packaging, p. 239-262. London: Elsevier Academic Press. https://doi.org/10.1016/B978-0-12-394601-0.00009-6

Hasdar, M., Erwanto, Y. and Triatmojo, S. (2011). Characteristics of edible films produced from combination gelatin skin chicken legs and soy protein isolate. *Bulletin of Animal Science,* 35(3), 188-196. https://doi.org/10.21059/buletinpeternak.v35i3.1092 [In Bahasa Indonesia].

Hasnelly, Nurminabari I.S. and Nasution M.E.U. (2015). Pemanfaatan whey susu menjadi edible film sebagai kemasan dengan penambahan CMC, gelatin dan plasticizer. *Pasundan Food Technology*, 2(1), 62-69. [In Bahasa Indonesia].

Ismawanti, R.D., Putri, W.D.R, Murtini, E.S. and Purwoto, H. (2020). Edible film made of corn starch-carrageenan-rice bran: The characteristic of formula's viscosity, water content, and water vapor transmission rate. *Teknologi dan Manajemen Agroindustri,* 9(3), 173-183.

Jacoeb, A.M., Nugraha, R. and Utari, S.P.S.D.U. (2014). Edible film from lindur fruit starch with addition of glycerol and carrageenan. *Jurnal Pengolahan Hasil Perikanan Indonesia,* 17(1), 14-21. https://doi.org/10.17844/jphpi.v17i1.8132 [In Bahasa Indonesia].

Julianto, G.E., Ustadi, U. and Husni, A. (2011). Characterization of gelatin edible film from skin of red nile by adding of sorbitol and palmitic acid as plasticiser. *Jurnal Perikanan*, 13(1), 27-34. [In Bahasa Indonesia].

Karouw, S., Rindengan, B., Kapu'Allo, M.L. and Wungkana, J. (2017). Properties of sago-based biodegradable film prepared by addition of glycerol, CMC, potassium sorbate and coconut oil. *Buletin Palma,* 18(1), 1-7. [In Bahasa Indonesia].

Krochta, J.M. and De Mulder-Johnston, C. (1997). Edible and biodegradable polymer film: Challenges and opportunities. *Food Technology,* 51(2), 61-74.

Layuk, P., Sondakh, J. and Pesireron, M. (2019). Characteristics and permeability properties of sago starch edible film. *Agritekno: Jurnal Teknologi Pertanian*, 8(2), 34-41. https://doi.org/10.30598/jagritekno.2019.8.2.34

Mali, S., Grossmann, M.V.E., Garcia, M.A., Martino, M.N. and Zaritzky, N.E. (2005). Mechanical and thermal properties of yam starch films. *Food Hydrocolloids,* 19(1), 157-164.

Meneguin, A.B., Cury, B.S.F. and Evangelista, R.C. (2014). Films from resistant starch-pectin dispersions intended for colonic drug delivery. *Carbohydrate Polymers,* 99, 140-149. https://doi.org/10.1016/j.carbpol.2013.07.077

Nugroho, A.A., Basito, B. and Anandito, R.B.K. (2013). Study the manufacture of tapioca edible films with the effect of addition of pectin some type in banana peels against mechanical and physical characteristics. *TeknoSains Pangan*, 2(1), 73-79. [In Bahasa Indonesia].

Pitak, N. and Rakshit, S.K. (2011). Physical and antimicrobial properties of banana flour/chitosan biodegradable and self-sealing films used for preserving freshcut vegetables. *LWT-Food Science and Technology*, 44(10), 2310-2315. https://doi.org/10.1016/j.lwt.2011.05.024

Polnaya, F.J., Talahatu, J., Haryadi., Marseno, D.W. and

Tuhumury, H.C.D. (2008). Karakterisasi sifat fisiko-kimia beberapa jenis pati sagu (*Metroxylon* sp.). Prosiding. Seminar Nasional Pengembangan Agroindustri Berbasis Sumberdaya Lokal untuk Mendukung Ketahanan Pangan. Malang, Indonesia: Universitas Brawijaya. [In Bahasa Indonesia].

Polnaya, F.J., Haryadi and Marseno, D.W. (2006). Edible film characterizations from native and modification sago starch. *Agritech*, 26(3), 148-154.

Polnaya, F.J., Haryadi, Marseno, D.W. and Cahyanto, M.N. (2012). Preparation and properties of sago starch phosphates. *Sago Palm,* 20(1), 3-11. https://doi.org/10.57418/sagopalm.20.1_3

Polnaya, F.J., Alfons, N.D.J. and Souripet, A. (2019). Characteristics of edible film from composite of molat sago starch-pectin. *Buletin Palma,* 20(2), 111-118. [In Bahasa Indonesia].

Setiani, W., Sudiarti, T. and Rahmidar, L. (2013). Preparasi dan karakterisasi edible film dari poliblend pati sukun-kitosan. *Valensi,* 3(2), 100-109. [In Bahasa Indonesia]. https://doi.org/10.15408/jkv.v3i2.506

Singh, N., Chawla, D. and Singh, J. (2004). Influence of acetic anhydride on physicochemical, morphological and thermal properties of corn and potato starch. *Food Chemistry*, 86(4), 601-608. https://doi.org/10.1016/j.foodchem.2003.10.008

Singh, T.P, Chatli, M.K. and Sahoo, J. (2015). Development of chitosan based edible films: process optimization using response surface methodology. *Food Science and Technology*, 52(5), 2530-2543. https://doi.org/10.1007/s13197-014-1318-6

Skurtys, O., Acevedo, C., Pedreschi, F., Enrione, J., Osorio F. and Aguilera, J.M. (2010). Food Hydrocolloid Edible Films and Coatings. New York, USA: Nova Science Publishers Inc.

Syarifuddin, A. and Yunianta. (2015). Characterization of edible film from grapefruit albedo pectin and arrowroot starch. *Pangan dan Agroindustri*, 3(4), 1538-1547. [In Bahasa Indonesia].

Rosida, Sudaryati and Yahya, A.M. (2018). Edible film from the pectin of papaya skin (The study of cassava starch and glycerol addition). *Journal of Physics IOP Conference Series*, 953, 012248. https://doi.org/10.1088/1742-6596/953/1/012248

Rumyaan, M., Polnaya, F.J. and Tuhumury, H.C.D. (2022). Characteristics of edible film made from bitter cassava starch with glycerol. *Agritekno: Jurnal Teknologi Pertanian*, 11(2), 102-107. https://doi.org/10.30598/jagritekno.2022.11.2.102

Uthumporn, U., Wahidah, N. and Karim, A.A. (2014). Physicochemical properties of starch from sago (*Metroxylon sagu*) palm grown in mineral soil at different growth stages. *IOP Conference Series: Materials Science and Engineering,* 62, 012026. https://doi.org/10.1088/1757-899X/62/1/012026

Warkoyo, Rahardjo, B., Marseno, D.W. and Karyadi, J.N.W. (2014). Physical, mechanical and barrier properties of xanthosoma sagittifolium starch-based edible film incorporated with potassium sorbate. *AGRITECH,* 34(1), 72-81. [In Indonesian]. Retrieved from https://jurnal.ugm.ac.id/agritech/article/view/9525

Wattimena, D., Ega, L. and Polnaya, F.J. (2016). Characteristics of edible film from native and phosphate sago starches with the addition of glycerol. *Agritech,* 36(3), 247-252. [In Bahasa Indonesia]. https://doi.org/10.22146/agritech.16661

Xu, Y.X., Kim, K.M., Hanna, M.A. and Nag, D. (2005). Chitosan-starch composite film: preparation and characterization. *Industrial Crops and Products,* 21 (2), 185-192. https://doi.org/10.1016/j.indcrop.2004.03.002

https://doi.org/10.26656/fr.2017.8(6).225