Journal of Technomaterial Physics
Journal homepage: https://talenta.usu.ac.id/JoTP

The Effect of Using a Combination of Sorbitol and Glycerol Plasticizers on the Characterization of Edible Film from Porang (*Amorphophallus oncophyllus*) Starch

Awan Maghfirah*, Sudiati, Silvya Nurrein K. Br Sitepu, and Meutia Widyanti Siambaton
Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan 20155, Indonesia.
*Corresponding Author: awan.maghfirah@usu.ac.id

ARTICLE INFO
Article history:
Received 16 June 2023
Revised 18 August 2023
Accepted 25 August 2023
Available online 31 August 2023

E-ISSN: 2656-0755
P-ISSN: 2656-0747

How to cite:
A. Maghfirah, Sudiati, S. N. K. Br Sitepu, and M. Widyanti, " The Effect of Using a Combination of Sorbitol and Glycerol Plasticizers on the Characterization of Edible Film from Porang (*Amorphophallus oncophyllus*) Starch," Journal of Technomaterial Physics, vol. 05, no. 02, pp. 86-92, Aug. 2023, doi: 10.32734/jotp.v5i2.12397.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International.
http://doi.org/10.32734/jotp.v5i2.12397

ABSTRACT
Edible films present an eco-friendly alternative for food packaging compared to traditional plastic materials. This study investigates the effects of glycerol and sorbitol plasticizers on the properties of edible films. The research involves crafting these films using porang (*Amorphophallus oncophyllus*) starch. Glycerol plasticizers were incorporated at a concentration of 100%, while sorbitol was utilized at varying levels (0%, 25%, 50%, 75%, 100%) to evaluate their impact on film characteristics. The films were produced using the melt intercalation method at a gelatinization temperature of 80°C and a firing temperature of 70°C. Notably, the most favorable physical test outcomes were observed with adding 100% sorbitol, including thickness, density, water absorption, and degradability improvements. Meanwhile, adding 25% sorbitol yielded the highest tensile strength and elongation values.

Keyword: Edible Film, Chitosan, Glycerol, Porang Starch, Sorbitol

ABSTRAK
Film yang dapat dimakan menghadirkan alternatif ramah lingkungan untuk kemasan makanan dibandingkan dengan bahan plastik tradisional. Penelitian ini menyelidiki pengaruh plasticizer gliserol dan sorbitol terhadap sifat-sifat edible film. Penelitian ini melibatkan pembuatan film-film ini menggunakan pati porang (*Amorphophallus oncophyllus*). Pemlastis gliserol digabungkan pada konsentrasi 100%, sedangkan sorbitol digunakan pada berbagai tingkat (0%, 25%, 50%, 75%, 100%) untuk mengevaluasi pengaruhnya terhadap karakteristik film. Film diproduksi menggunakan metode interkalasi lelehan pada suhu gelatinisasi 80°C dan suhu pembakaran 70°C. Khususnya, hasil uji fisik yang paling menguntungkan diamati dengan menambahkan sorbitol 100%, termasuk peningkatan ketebalan, densitas, penyerapan air, dan degradabilitas. Sedangkan penambahan sorbitol 25% menghasilkan nilai kekuatan tarik dan elongasi tertinggi.

Kata Kunci: Edible Film, Gliserol, Kitosan, Pati Porang, Sorbitol

1. Introduction

Petroleum-based synthetic plastics have the property of not being easily decomposed in nature. It takes hundreds of years for synthetic plastic to decompose entirely in nature, so plastic waste builds up quickly in the environment. The accumulation of plastic waste that interacts with water and other substances then pollutes the soil and damages water quality [1]. In 2022, plastic waste generation in Indonesia will reach 3.4 million tons. Edible films are expected to be a solution to the use of synthetic plastics [2].

Materials used as edible film include starch, cellulose, and protein [3]. One type of starch that can be used is starch from porang tubers (*Amorphophalus oncophillus*). Starch tends to dissolve in water so that the edible film produced is easily degraded by microorganisms [4]. In addition, because the number of root crops is very abundant in Indonesia, the starch used as a raw material for making sample edible film is appropriate [5].

The addition of plasticizers was carried out to increase elasticity and weaken the stiffness [6]. Glycerol plasticizer was outperformed by sorbitol plasticizer in terms of the elongation of edible film, and at the same concentration, sorbitol plasticizer was superior in terms of tensile strength [7]. Using a combination of sorbitol and glycerol plasticizers produced the best value for tensile strength when the percentage of glycerol plasticizer was less than that of sorbitol. At the same time, the best value for elongation at break using a glycerol plasticizer is more than sorbitol [8].

2. Method

2.1. The Process Of Preparing Tubers To Become Porang Starch

In order to obtain the porang starch, porang was washed and peeled the porang tubers obtained, then cut into pieces and added to water to be pureed using a blender. Filter the results of the mashed porang with gauze and settle for 24 hours by adding distilled water. Wash thoroughly with distilled water every 5 hours until the residue is white. The white starch precipitate was dried over 24 hours in an oven at 60°C. Once the starch has dried, crush it and sift it through a 200 mesh sieve to make a puree. Porang starch is ready to be analyzed for starch content, water absorption, protein, and fat content.

2.2. Process For Making Edible Films

In order to make edible films, the sample was prepared, and the ingredients were weighted according to the composition. The total mass of chitosan and starch is 5 grams; in this study, the ratio is 70%:30% (w/w). The starch solution was made using distilled water and a 1:20 (w/v) ratio. Chitosan solution was prepared with a ratio of 2% chitosan and acetic acid (1:40 w/v). Plasticizer was prepared using glycerol 100% of 5 grams and the addition of variations of plasticizer sorbitol 0%, 25%, 50%, 75%, and 100% of the percent glycerol. The starch solution was mixed into a beaker glass containing chitosan solution, after which glycerol and sorbitol plasticizers were added according to the composition into the chitosan starch solution slowly on a hot plate while stirring with a magnetic stirrer at 400 rpm until homogeneous with a gelatinization temperature of 80. Once homogeneous, the magnetic stirrer is turned off. Pour as much solution as possible into a 15 x 20 cm glass mold, leave it at room temperature for a while, then bake it for 24 hours in the oven at 70°C. After the sample is dry, the sample in the mold is removed and put into the desiccator. Then various measurements of edible film were carried out, and the data was analyzed.

3. Results and Discussion

3.1. Results of Porang Starch Content Analyzed

From 1 kg of porang tubers analyzed in this study, 152 grams, or as much as 15.2%, were obtained. The starch content of porang obtained in Maghfirah's study [9] was 14.517%. The study's results showed a greater starch content Shafqat [10] asserts that the sample degradation value increases with the amount of starch used to make edible films.

3.2. Porang Starch Water Content

The water content value of porang starch obtained in the analysis in this study was 0.067% of 2 grams of porang starch. The starch water content in this study fulfilled the SNI 3451: 2011 standard, which states that the maximum water content in starch is 14%. According to Daud [11], reducing the water content of food ingredients will reduce water availability to support the life of microorganisms and also for physicochemical reactions to take place so that the resulting edible film is of higher quality.

3.3. Porang Starch Protein Content

In testing the protein content of porang starch, the results obtained were 0.698% of 1 gram of porang starch. According to Dewi [12], a low protein content has a low water vapor permeability value and a high oxygen permeability, making it a good water barrier, but it is ineffective at retaining gas.

3.4. Porang Starch of Fat Content

For the analysis of the fat content of porang starch, results of 0.52% were obtained from 2 grams of the substance. Whether excessive or low, the amount of starch fat produced is one of the factors Rostianti [13] claims influence the quality of the starch and flour produced. Because oxidation reactions do not quickly degrade starch with high-fat content, the resulting edible film can protect food ingredients for longer.

3.5. Measuring The Thickness of Edible Porang Starch Film

Using the modification (ASTM D 1005), five points on the surface of the edible film are measured, then the test results from the five points are averaged to obtain the average thickness value of one bioplastic sample.

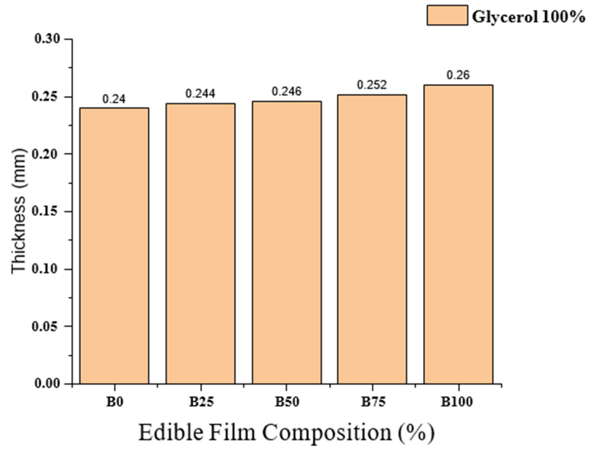

Figure 1. Chart depicting the relationship between edible film composition and thickness.

From Figure 1, we can see that the edible film becomes very thick in value as it is seen that the concentration of sorbitol plasticizer increases because the higher percentage of plasticizer added to the edible film constituent solution will increase the dissolved solids in the solution, so that it will affect its thickness. According to Unsa and Paramastri [14], the addition of plasticizer concentration will increase the polymer making up the matrix of the solution to be printed so that the thickness of the edible produced also increases.

3.6. The Density of Edible Film

The mass density test uses (ASTM D 792), which measures the mass of each volume unit. The mass is obtained by weighing the edible film. The volume is obtained from the length times the average thickness obtained times the breadth of the edible film.

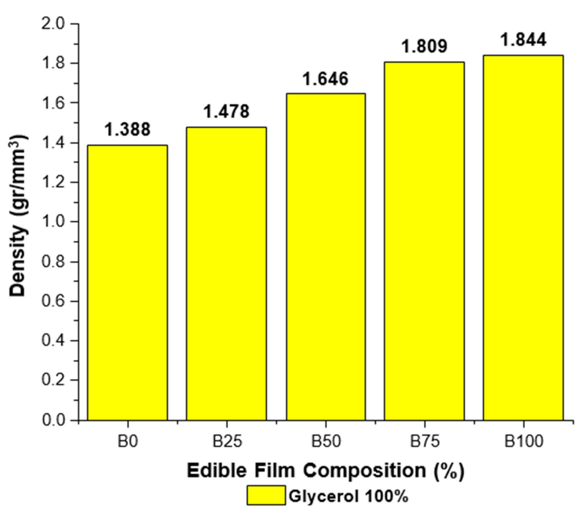

Figure 2. Chart depicting the relationship between edible film composition and density.

From Figure 2, it can be seen that along with the increase in the percentage of glycerol and sorbitol plasticizers which increased the thickness of the bioplastic, the resulting mass density also increased. High mass density results in a smaller pore structure in bioplastic cells, making it more difficult to dissolve in water, and its water absorption will be lower. This is in line with the statement by Putra and Thamrin [15] that the resulting density data demonstrates the ability of bioplastic films to protect the products they pack from free air.

3.7. The Water Absorption of Edible Film

This water absorption ability test uses a modification (ASTM D570-98). Water absorption was tested by cutting a sample of edible film measuring 2 cm × 5 cm and weighing its mass before immersing it in distilled water, then soaking the sample in sufficient aqua dest and observing changes in the sample. Based on the test results, the samples were soaked for 3 minutes, removed, and allowed to stand for 24 hours. After that, the final sample mass was weighed for the water absorption test.

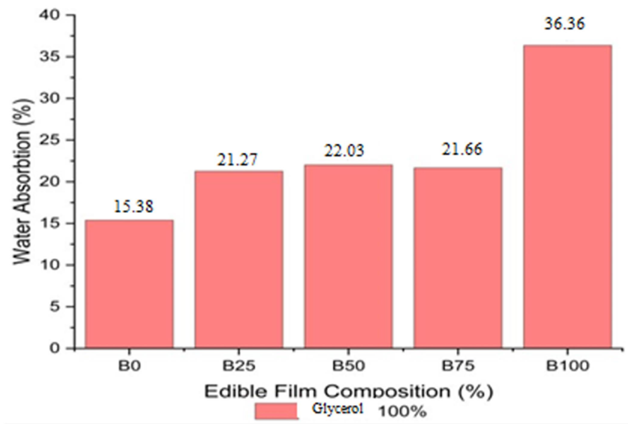

Figure 3. Chart depicting the relationship between edible film composition and water absorption.

From Figure 3, it can be seen that along with the increase in the number of plasticizer cells, the absorption of water obtained is also higher because the plasticizers, both sorbitol, and glycerol, have high solubility properties of cells, thereby enhancing the water resistance value of the bioplastics produced. This was followed by research by Purnavita and Dewi [16] that the addition of plasticizers to starch ratios had the effect of strengthening resistance to water because the presence of plasticizers would loosen the bonds between the amylose cells' amylose molecules so that there is a possibility of gaps and water can enter.

3.8. Tensile Strength of Edible Film

Edible film tensile strength test using (ASTM D882-18). The edible film was cut with a size of 2 cm × 10 cm, then clamped using a tensile strength tester (UlTM RTF 1350), and then the results were recorded based on the maximum load that could be loaded on the sample.

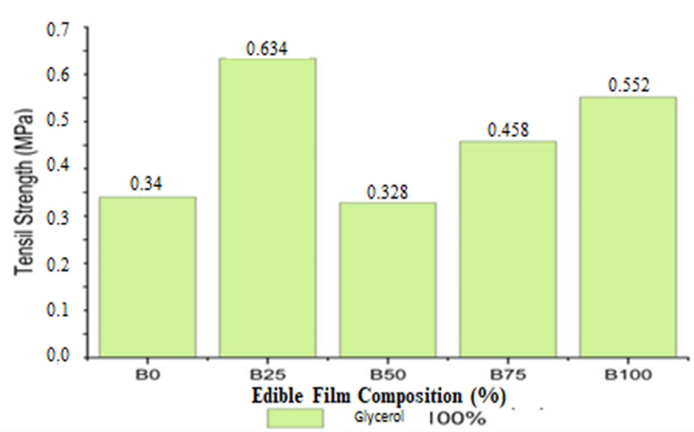

Figure 4. Chart depicting the relationship between edible film composition and tensile strength.

From Figure 4, the tensile strength value shows that the tensile strength test results decreased with increasing sorbitol plasticizer variations when using 100% glycerol. The highest tensile strength value was found in the 25% sorbitol addition variation with a value of 0.634 MPa, while the lowest value was in the

50% sorbitol addition variation with a value of 0.328 MPa. This is supported by the results of Purbasari's research, which showed that glycerol has a better plasticizing ability than sorbitol. So the use of sorbitol decreases the tensile strength of the edible film.

3.9. Results of Measurements of Elongation At Break

Elongation test using (ASTM D822-10), the edible film sample is cut with a size of 2 cm × 10 cm, which is placed on the clamp of the tensile strength test tool. The elongation value is obtained by calculating the ratio between the increase in length after breaking and the initial length of the edible film. Data from the elongation test are obtained in the following graph.

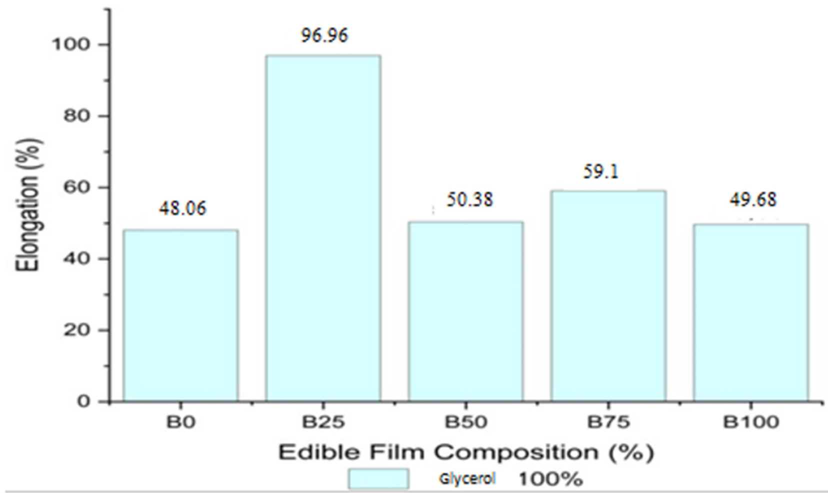

Figure 5. Chart depicting the relationship between edible film composition and elongation.

From Figure 5, the elongation value decreased with the extra sorbitol variations, with the best value being 25% sorbitol and 100% glycerol at 96.96%. Unsa and Paramastri supports this by saying that the addition of more and more plasticizers will affect the cohesion bonds between polymers that will be smaller, and the films formed will become softer so that the edible films formed will be easily broken [14].

3.10. Ability To Degrade Edible Starch Porang Films

This biodegradability test was carried out for 4 weeks or 28 days, where the bioplastic sample was cut into 2.5×2.5 cm sizes and then weighed for mass before planting it in the soil. Furthermore, the decrease in sample mass will be calculated every week.

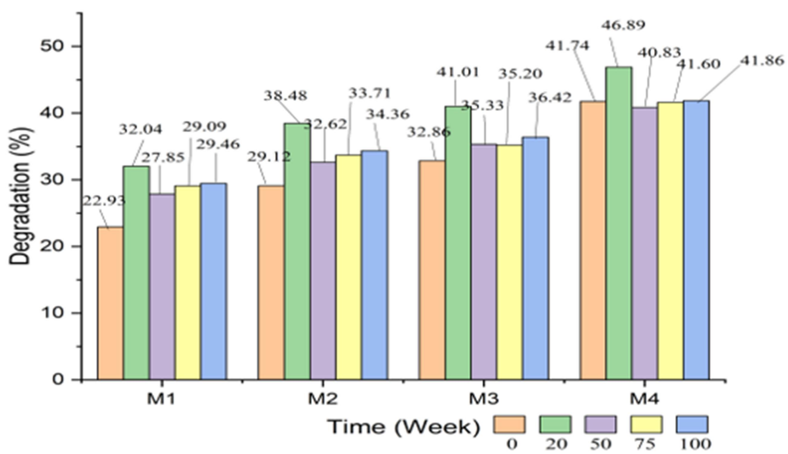

Figure 6. Chart depicting the relationship between edible film composition and biodegradation.

Figure 6, along with the extra glycerol and sorbitol, which reduced the value of the edible film's resistance to water, increased water absorption, thereby increasing the percent degradation of the edible film obtained. This is in accordance with Syiami et al. statement [17], which states that adding sorbitol can accelerate the decomposition time of plastic in the soil because it is related to the ability of bioplastics to absorb bacterial solutions.

4. Conclusion

Research has been successfully carried out to see the effect of adding glycerol and sorbitol plasticizers on the characterization of porang starch edible films. The highest physical test results obtained were the use of 100% glycerol plasticizer and the addition of 100% sorbitol, including a thickness value of 0.260 mm, a density of 1.844 g/mm^3, and a water absorption capacity of 36.36%. The highest values for tensile strength, elongation, and degradability were 25% extra sorbitol with a tensile strength of 0.634 MPa, an elongation value of 96.96%, and an edible film degradability of 46.89%.

References

[1] M. K. Marichelvam, M. Jawaid, and M. Asim, "Corn and Rice Starch-Based Bio-Plastic as Alternative Packaging Materials," *Fibers*, vol. 7, no. 4, pp. 32, 2019, doi: 10.3390/fib7040032.

[2] S. X. Tan, A. Andriyana, H. C. Ong, S. Lim, Y. L. Pang, and G. C. Ngoh, "A Comprehensive Review on the Emerging Roles of Nanofillers and Plasticizers towards Sustainable Starch-Based Bioplastic Fabrication," *Polymers*, vol. 14, no. 4, pp. 664, 2022, doi: 10.3390/polym14040664.

[3] M. Mroczkowska, D. Culliton, K. Germaine, and A. Neves, "Comparison of Mechanical and Physicochemical Characteristics of Potato Starch and Gelatine Blend Bioplastics Made with Gelatines from Different Sources," *Clean Technologies*, vol. 3, no. 2, pp. 424–436, 2021, doi: 10.3390/cleantechnol3020024.

[4] J. Budiman, R. Nopianti, and S. D. Lestari, "Karakteristik Bioplastik dari Pati Buah Lindur (*Bruguiera gymnorrizha*)," *Jurnal Fishtech*, vol. 7, no. 1, pp. 49–59, 2018, doi: 10.36706/fishtech.v7i1.5980.

[5] D. I. Lailyningtyas, M. Lutfi, and A. M. Ahmad, "Uji Mekanik Bioplastik Berbahan Pati Umbi Ganyong (*Canna edulis*) dengan Variasi Selullosa Asetat dan Sorbitol," *Jurnal Keteknikan Pertanian Tropis dan Biosistem*, vol. 8, no. 1, pp. 91–100, 2020, doi: 10.21776/ub.jkptb.2020.008.01.09.

[6] Z. Azizati, I. M. Z. Afidin, and L. A. Hasnowo, "The Effect of Sorbitol Addition in Bioplastic from Cellulose Acetate (*Sugarcane bagasse*)-Chitosan," *Walisongo Journal of Chemistry*, vol. 5, no. 1, pp. 94–101, 2022, doi: 10.21580/wjc.v5i1.12173.

[7] A. Purbasari, A. A. Wullandari, and F. M. Marasabessy, "Sifat Mekanis dan Fisis Bioplastik dari Limbah Kulit Pisang: Pengaruh Jenis dan Konsentrasi Pemlastis," *Jurnal Kimia dan Kemasan*, vol. 42, no. 2, pp. 66-73, 2020, doi: 10.24817/jkk.v42i2.5872.

[8] A. Asngad, E. J. Marudin, and D. S. Cahyo, "Kualitas Bioplastik dari Umbi Singkong Karet dengan Penambahan Kombinasi Plasticizer Gliserol dengan Sorbitol dan Kitosan," *Bioeksperimen: Jurnal Penelitian Biologi*, vol. 6, no. 1, pp. 36-44, 2020, doi: 10.23917/bioeksperimen.v6i1.10431.

[9] A. Maghfirah, A. Mitri, K. Brahmana, and Sudiati, "Effect of Gelatinization Temperature on the Physical Properties of Porang (*Amorphophallus oncophyllus*) Starch Bioplastics with Sorbitol Plasticizer," *J. Technomaterial Phys.*, vol. 5, no. 1, pp. 33–38, 2023, doi: 10.32734/jotp.v5i1.10217.

[10] A. Shafqat, N. Al-Zaqri, A. Tahir, and A. Alsalme, "Synthesis and Characterization of Starch Based Bioplatics Using Varying Plant-Based Ingredients, Plasticizers and Natural Fillers," *Saudi J. Biol. Sci.*, vol. 28, no. 3, pp. 1739–1749, 2021, doi: 10.1016/j.sjbs.2020.12.015.

[11] A. Daud, Suriati, and Nuzulyanti, "Kajian Penerapan Faktor yang Mempengaruhi Akurasi Penentuan Kadar Air Metode Thermogravimetri," *Lutjanus*, vol. 24, no. 2, pp. 11–16, 2019, doi: 10.51978/jlpp.v24i2.79.

[12] R. Dewi, Rahmi, and Nasrun, "Perbaikan Sifat Mekanik dan Laju Transmisi Uap Air Edible Film Bioplastik Menggulnakan Minyak Sawit dan Plasticizer Gliserol Berbasis Pati Sagu," *Jurnal Teknologi Kimia Unimal*, vol. 10, no. 1, pp. 61-77, 2021, doi: 10.29103/jtku.v10i1.4177.

[13] T. Rostianti, D. N. Hakiki, A. Ariska, and Sumantri, "Karakterisasi Sifat Fisikokimia Tepung Talas Beneng sebagai Biodiversitas Pangan Lokal Kabupaten Pandegang," *Gorontalo Agriculture Technology Journal*, vol. 1, no. 2, pp. 1-7, 2018, doi: 10.32662/gatj.v1i2.417.

[14] L. K. Unsa, and G. A. Paramastri, "Kajian Jenis Plasticizer Campuran Gliserol dan Sorbitol Terhadap Sintesis dan Karakterisasi Edible Film Pati Bonggol Pisang sebagai Pengemas Buah Apel," *Jurnal Kompetensi Teknik*, vol. 10, no. 1, pp. 35–47, 2018, doi: 10.15294/jkomtek.v10i1.17368.

[15] E. P. D. Putra and E. S. Thamrin, "Sifat Fisik dan Mekanik Bioplastik dari Pati Kulit Pisang Ambon (*Musa paradisiacal*) dengan Plasticizer Sorbitol," *Agroindustrial Technology Joulrnal*, vol. 6, no. 2, pp. 164–174, 2022, doi: 10.21111/atj.v6i2.7819.

[16] S. Purnavita and V. C. Dewi, "Kajian Ketahanan Bioplastik Pati Jagung dengan Variasi Berat dan Suhu Pelarutan Polivinil Alkohol," *Chemtag: Journal of Chemical Engineering*, vol. 2, no. 1, pp. 14-22, 2021.

[17] D. Syiami, R. Handayani, and A. Najihudin "Pengaruh Plastisizer Terhadap Elastisitas dan Kelenturan Edible Film," *Jurnal Kesehatan Madani Medika*, vol. 12, no. 02, pp. 152–158, 2021, doi: 10.36569/jmm.v12i2.190.