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

Effect of Gelatinization Temperature on the Physical Properties of Porang (*Amorphophallus oncophyllus*) Starch Bioplastics with Sorbitol Plasticizer

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ARTICLE INFO

Article history:
Received 04 February 2023
Revised 20 February 2023
Accepted 24 February 2023
Available online 28 February 2023

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

How to cite:
A. Maghfirah and A. Mitri "Effect of Gelatinization Temperature on the Physical Properties of Porang (Amorphophallus oncophyllus) Starch Bioplastics with Sorbitol Plasticizer," Journal of Technomaterial Physics, vol. 05, no. 01, Feb. 2023, doi:10.32734/jotp.v5i1.10217.

ABSTRACT

Bioplastics are plastics that can be used like conventional plastics but can be more easily decomposed in the soil. Studies have been conducted to determine the effect of temperature variations in the gelatinization of porang starch on the manufacture of bioplastics with sorbitol plasticizers on their characterization. In this study, bioplastics have been produced, which are made with variations in the composition of starch: chitosan (30:70) %, (40:60) %, (50:50) %, (60:40) %, and (70:30) % with the addition of sorbitol as a plasticizer and heating process at gelatinizing temperature variations of 70 ° C, 80 ° C, and 90 ° C. The results showed that the gelatinization temperature variation affects bioplastic water's thickness, density, and absorbency. Where the higher the temperature of gelatinization, the thickness of the bioplastics will decrease, the density of bioplastics will increase, and the absorption of bioplastic water will decrease.

Keyword: Bioplastic, Gelatinization, Porang

ABSTRAK

Bioplastik adalah plastik yang dapat digunakan seperti plastik konvensional namun dapat lebih mudah terurai di dalam tanah. Telah dilakukan penelitian untuk mengetahui pengaruh variasi suhu pada gelatinisasi pati porang pada pembuatan bioplastik dengan plasticizer sorbitol terhadap karakterisasinya. Pada penelitian ini telah dihasilkan bioplastik yang dibuat dengan variasi komposisi pati: kitosan (30:70) %, (40:60) %, (50:50) %, (60:40) %, dan (70:30) % dengan penambahan sorbitol sebagai plasticizer dan proses pemanasan pada variasi temperatur gelatinisasi 70°C, 80°C, dan 90°C. Hasil penelitian menunjukkan bahwa variasi temperatur gelatinisasi berpengaruh terhadap ketebalan, densitas, dan daya serap air bioplastik. Dimana semakin tinggi suhu gelatinisasi maka ketebalan bioplastik akan semakin berkurang, densitas bioplastik akan meningkat, dan daya serap air bioplastik semakin menurun.

Kata Kunci: Bioplastik, Gelatinisasi, Porang

1. Introduction

Plastic pollution is a global concern as plastic waste is now ubiquitous. While plastic materials have many advantages that make plastic difficult to separate from human life. The composition of plastic waste in Indonesia is 15.6% in 2021 consisting of 222 regencies/cities throughout Indonesia. If the waste generation in Indonesia is 28,533,787.04 tons/year, then Indonesia disposes of plastic waste as much as 4,451,270.78 tons/year [1]. Researchers estimate more than 8.3 billion tons of plastic have been produced since the early 1950s. Only 9% of all plastic waste ever generated has been recycled. About 12% have been burned, while the remaining 79% have accumulated in landfills or natural environments [2].

According to research, excessive use of plastic will cause various health problems, because it can result in cancer triggers and tissue damage to the human body (carcinogenic). In addition, plastics in general are difficult to degrade (decompose) by microorganisms. This plastic waste takes several generations of life until hundreds of years can only be decomposed or perfectly decomposed by the soil [3]. Therefore, as one of the efforts to reduce the amount of plastic waste accumulation, researchers have proposed replacing conventional plastics with bio-based or biodegradable plastics that are more environmentally friendly.

Today, bioplastics produced from natural and environmentally friendly biopolymers such as cellulose, starch, protein, lactic acid, hydroxy alkanoic, or other materials of plant origin or microorganisms have become a very interesting topic among researchers around the world [4]. Bioplastics are plastics that can be used like conventional plastics but are more easily decomposed by microorganisms into the water and carbon dioxide without leaving toxic substances [5]. Starch is a semi-crystal biopolymer that serves as a carbohydrate reserve in various crops including seeds, cereals, roots, and tubers [6].

Porang tubers are one of the local commodity materials that can be mandated in the process of making bioplastics. Porang plant (Amorphophallus Oncophyllus) is classified as a root crop that is included in the Araceae family category with a relatively high glucomannan content of 15-64% dry base [7]. Glucomannan is a water-soluble dietary fiber that has strong hydrocolloid properties and is low in calories [8]. The use of porang tubers in flour products is one of the options to facilitate storage and alternative processing into advanced products [7].

In the manufacture of bioplastics, a gelatinization process occurs, namely when the crystalline starch structure breaks, the granule absorbs water then swells and cannot return to its original shape [6]. Gelatinization of starch results in granular swelling, crystal melting, loss of birefringence, viscosity development, and solubility [9]. Optimization of the use of temperature variations in the gelatinization process is expected to improve the physical and mechanical properties of bioplastics [10].

2. Method

2.1. Preparation of porang tubers into starch

The porang tubers to be taken are then washed thoroughly and peeled from the peel and then cut into chips. After cutting the porang chips, then add the porang chips with water and grind using a blender. Filter the porang that has been smoothed with gauze and precipitate the porang for 24 hours then precipitate in the form of starch and dry the starch in the oven for 24 hours at a temperature of 60 °C. After the starch dries then grind the starch with a blender then sift with a 200 mesh sieve and analyze to see the starch content, moisture content, protein, and fat content.

2.2. Bioplastic Manufacturing

Weighed a certain amount of starch and chitosan mass with a total mass of starch and chitosan which is 5 grams. Then a starch solution is made with a starch and distilled water ratio is 1:20 (w/v). Then dissolved chitosan which has been weighed into a solution of acetic acid 0.1 M (1:40 w/v). With a variation in gelatinization temperature of 70°C, 80°C, and 90°C which will be used with a magnetic stirrer rotation speed of 400 rpm for 30 minutes. The starch solution is slowly added to the mixture. Sorbitol was added after 30 minutes with a concentration of 40% (v/w) in the starch-chitosan solution, then stirred for 15 minutes, then turned off the magnetic stirrer. Poured as much solution into the mold, then in the oven at a temperature of 60 ˚C for 24 hours. After drying, it is removed and put the sample into the desiccator for 24 hours. Then the bioplastics are removed from the mold and then analyzed the data.

3. Result and Discussion

3.1. Porang starch content

In this study, 14.517 g of starch was obtained from 100 g of porang, or as much as 14.517%. When compared to the study [8] the content of porang starch obtained was 8.49%, the starch content obtained in this study was still higher. The quality of the starch produced is strongly influenced by the extraction process [11]. In addition, the age of the tuber harvest is also very influential on the decrease in starch yield [12]. According to Shafqat et al [13], the higher the starch content used in the manufacture of bioplastics, the more degradability it will increase its degradability.

3.2. The moisture content of porang starch

The results of the analysis of the moisture content of porang starch were obtained by 5.71% of 1 g of porang starch. The lower the moisture content of starch, the better the quality of the starch because the high-water content in the starch will cause bacteria and fungi to multiply easily. According to Husna et al [14] materials with low moisture content will last longer (last), and low water content will make it difficult for putrefactive bacteria to multiply.

3.3. Porang Starch protein content

In testing protein levels carried out using the Kjedahl method, protein levels of 0.74% of 2 g of porang starch were obtained. When compared to the study of Nurmiati et al [15] with a protein content of 0.57% of sago starch by the same method, the protein content obtained in this study was still higher. According to Polnaya et al [16] the low protein content can be caused by water-soluble proteins found in the pulp that is removed during the starch extraction process.

3.4. Fat Content of Porang Starch

In testing fat content carried out using the Soxhlet method, a fat content of 5.23% of 2 g of porang starch was obtained. When compared to the study of Yuniwati et al [8] the fat content obtained was 5.68% of porang flour, the fat content of porang starch obtained in this study was still lower. According to Husna et al [14] the low-fat content means that the quality of the flour is relatively more stable since it is not prone to damage and rancidity.

3.5. The thickness of bioplastic

Thickness measurement using Microcal Meshmer (ASTM D-1005) was carried out by measuring at five different points in bioplastics, and the results were obtained from the average of the five measurements. Measurement of bioplastic thickness in this study was carried out using a screw micrometer that has an accuracy of 0.01 mm.

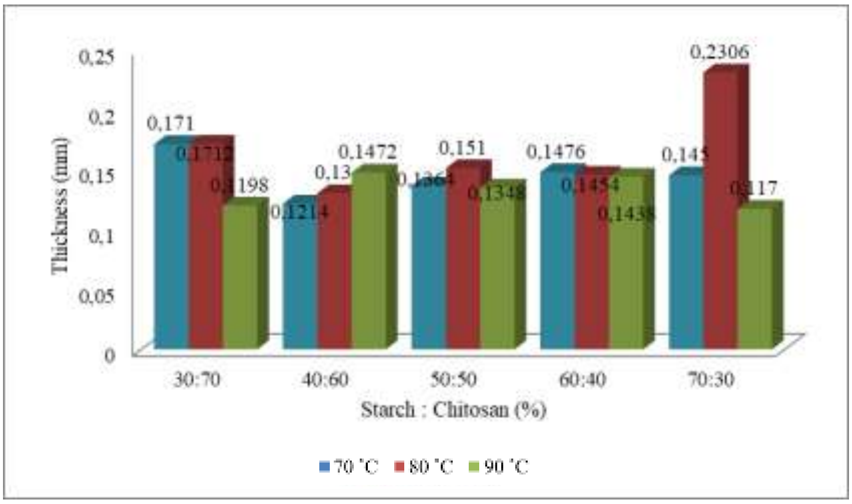

Figure 1. Porang Starch Bioplastic Thickness Graph.

From Fig.1 The thickness of the bioplastic starch obtained is volatile. Variations in gelatinization temperatures do not show a significant influence on the thickness of bioplastics. The higher the temperature of the gelatinization used; the thickness of the bioplastics tends to decrease. According to Dewi et al [17] the diversity of temperatures and the duration of gelatinization and the interaction of the two showed no noticeable effect on the thickness of the bioplastics. The higher the temperature of the gelatinization causes the thickness of the bioplastics to decrease because when warming up the high temperature causes more water vapor to come out of the starch so that the less water content in the bioplastics.

3.6. Density of bioplastic

Density testing using ASTM D 792-08 was performed by measuring the mass of each unit of volume.

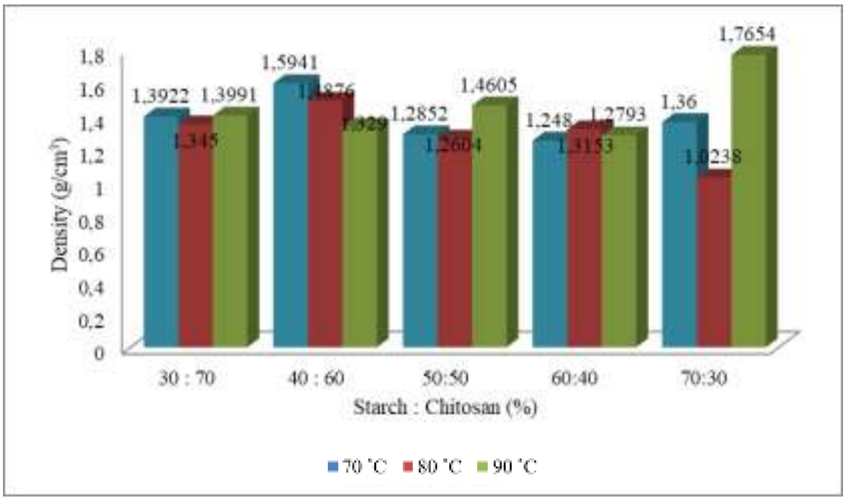

Figure 2. Porang Starch Bioplastic Density Analysis Graph.

Based on Figure 2, it can be seen that the higher the temperature of gelatinization, the density of bioplastics tends to increase. According to Dewi et al [17] The higher the temperature of the gelatinization causes the bioplastics to get stickier or the pores to get tighter.

3.7. Water Absorption Test

Water absorption testing is carried out by cutting bioplastics with a size of 1 cm x 1 cm and weighing the initial mass of bioplastics, then immersed in ±10 mL of distilled water for 10 minutes, and dried and then weighed the final mass of bioplastics.

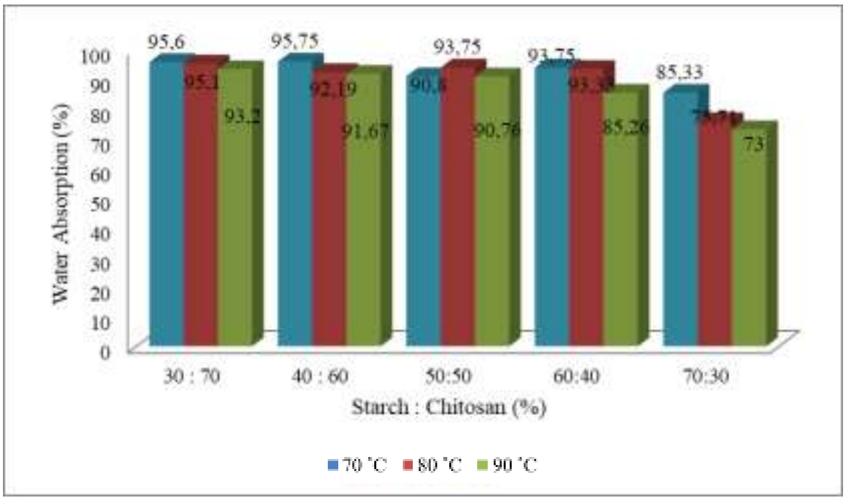

Figure 3. Bioplastic Water Absorption Power Graph of Porang Starch.

Based on Figure 3, it can be seen that the higher the temperature of the gelatinization used, the lower the water absorption of the bioplastics. According to Setiani et al [18] the higher the temperature of the gelatinization, the greater the evaporation of water from the gel that the bioplastic surface structure is made. This evaporation of water causes the bioplastics to get tighter. The tighter the bioplastics will cause less water to be absorbed. The higher the ability of bioplastics to absorb water, the lower the quality of the bioplastics, as this is related to the resistance of bioplastics when stored [19].

3.8. Biodegradation analysis of bioplastic

Biodegradability testing was carried out for 28 days of burial in the soil, then calculated the mass reduction that occurred in each week.

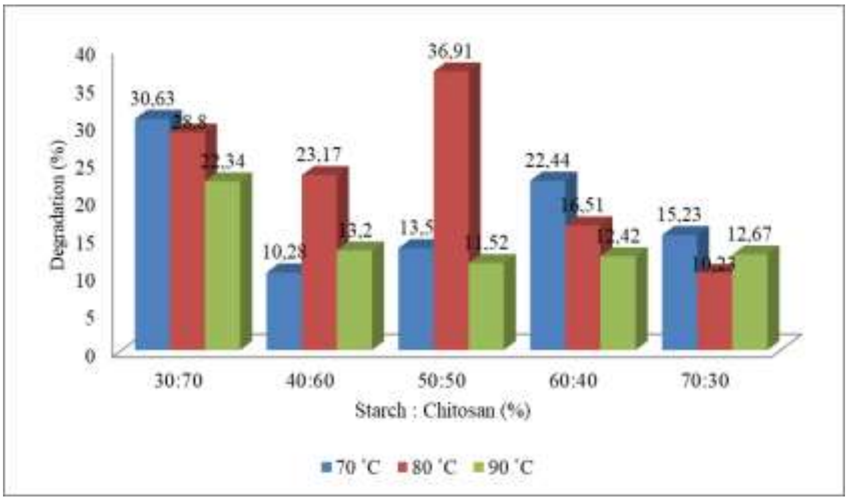

Figure 4. Graph of Bioplastic Biodegradation Analysis of Porang Starch.

Based on Figure 4, the percent of bioplastic degradation is affected by a rise in the temperature of gelatinization, where the higher the temperature of the gelatinization used, the percent of degradation produced tends to be smaller. According to Dewi et al [17] the higher the temperature causes the bioplastics to become stickier or the pores to get tighter and bind so that they take longer for degradation.

4. Conclusion

Porang (*Amorphophallus oncophyllus*) starch-based bioplastics were successfully produced by adding sorbitol plasticizer from chitosan. The starch content in the composition was found to be approximately 14.517% from porang, with a corresponding water content of approximately 5.71%. In contrast, the protein content in porang starch was measured at only 0.74%, and the fat content was found to be 5.23%. Additionally, the resulting bioplastic had a maximum thickness of 0.2306 mm, a maximum density of 1.7654 g/cm^3, the lowest water absorption value of 73.00%, and the highest degradation value of 36.91%.

References

[1] SIPSN, "Capaian Kinerja Pengelolaan Sampah," *Sistem Informasi Pengelolaan Sampah Nasional*, 2021. [Online]. Available: https://sipsn.menlhk.go.id/sipsn/.

[2] R. Geyer, J. R. Jambeck, and K. L. Law, "Production, use, and fate of all plastics ever made," *Sci. Adv.*, vol. 3, no. 7, pp. 3–8, 2017, doi: 10.1126/sciadv.1700782.

[3] R. A. A. Gunadi, D. P. Parlindungan, A. U. Parta Santi, Aswir, and A. Aburahman, "Bahaya Sampah Plastik bagi Kesehatan dan Lingkungan," in *Seminar Nasional Pengabdian Masyarakat LPPM UMJ*, 2020, vol. 1, no. UMJ-PAI-103, pp. 1–8.

[4] S. Nigam, A. K. Das, and M. K. Patidar, "Synthesis, characterization and biodegradation of bioplastic films produced from Parthenium hysterophorus by incorporating a plasticizer (PEG600)," *Environ. Challenges*, vol. 5, p. 100280, 2021, doi: 10.1016/j.envc.2021.100280.

[5] A. Melani, N. Herawati, and A. F. Kurniawan, "Bioplastik Pati Umbi Talas Melalui Proses Melt Intercalation (Kajian Pengaruh Jenis Filler, Konsentrasi Filler dan Jenis Plasticiezer)," *Distilasi*, vol. 2, no. 2, pp. 53–67, 2017.

[6] N. Diniyah, P. G. V. Ganesha, and A. Subagio, "Pengaruh Perlakuan pH dan Suhu Terhadap Sifat Fisikokimia Mocaf (Modified Cassava Flour)," *J. Penelit. Pascapanen Pertan.*, vol. 16, no. 3, pp. 147–158, 2019, doi: 10.21082/jpasca.v16n3.2019.147-158.

[7] M. A. Ferdian and S. Farida, "Karakteristik Edible Film dari Tepung Porang Termodifikasi sebagai Kemasan Bumbu Mi Instan," in *Prosiding seminar nasional teknologiindustri, lingkungan dann infastruktur (SENTIKUIN)*, 2021, vol. 4, pp. 1–8.

[8] I. Yuniwati, D. R. Pamuji, E. Trianasari, N. S. Rahayu, and Y. Ulfiyati, "Pembuatan tepung porang sebagai upaya peningkatan penjualan umbi porang di masa pandemi covid19," *J. Inov. Has. Pengabdi. Masy.*, vol. 4, no. 2, pp. 231–240, 2021, doi: 10.33474/jipemas.v4i2.9368.

[9] R. Megavitry and N. Nurhijrah, "The Process of Developing Gelatinization and Saccharification with Variations in Temperature and Period of Glucose Sago Material," *Int. J. Environ. Eng. Educ.*, vol. 1, no. 3, pp. 82–89, 2019, doi: 10.55151/ijeedu.v1i3.20.

[10] D. M. Dwi Pradana Putra, B. A. Harsojuwono, and A. Hartiati, "Studi Suhu dan pH Gelatinisasi pada Pembuatan Bioplastik dari Pati Kulit Singkong," *J. Rekayasa dan Manaj. Agroindustri*, vol. 7, no. 3,

pp. 441–449, 2019, doi: 10.24843/jrma.2019.v07.i03.p11.

[11] N. RAHMAN, H. Fitriani, Hartati, and N. S. Hartati, "Seleksi ubi kayu berdasarkan perbedaan waktu panen dan inisiasi kultur in vitro," in *Pros Sem Nas Masy Biodiv Indon*, 2015, vol. 1, no. 8, pp. 1761–1765, doi: 10.13057/psnmbi/m010803.

[12] N. R. Anggraini, E. Yuliadi, K. Setiawan, M. Syamsoel, and Hadi, "Karakterisasi Pertubuhan , Kandungan Pati , dan Kadar HCN Berbagai Klon Ubikayu (Manihot esculenta Crantz)," *J. trofical Upld Resour.*, vol. 03, no. 01, pp. 45–53, 2021.

[13] A. Shafqat, A. Tahir, A. Mahmood, A. B. Tabinda, A. Yasar, and A. Pugazhendhi, "A review on environmental significance carbon foot prints of starch based bio-plastic: A substitute of conventional plastics," *Biocatal. Agric. Biotechnol.*, vol. 27, p. 101540, 2020, doi: 10.1016/j.bcab.2020.101540.

[14] A. Husna, L. Handayani, and F. Syahputra, "Pemanfaatan tulang ikan kambing-kambing (Abalistes stellaris) sebagai sumber kalsium pada produk tepung tulang ikan," *Acta Aquat. Aquat. Sci. J.*, vol. 7, no. 1, pp. 13–20, 2020, doi: 10.29103/aa.v7i1.1912.

[15] Nurmiati, S. Raharja, and P. Suryadarma, "Peningkatan Sifat Fungsional Pati Sagu (Metroxylon Sp.) Melalui Penambahan Isolat Protein Kedelai Dan Transglutaminase," *J. Teknol. Ind. Pertan.*, vol. 30, no. 2, pp. 190–197, 2020, doi: 10.24961/j.tek.ind.pert.2020.30.2.190.

[16] F. J. Polnaya, R. Breemer, G. H. Augustyn, and H. C. D. Tuhumury, "Karakteristik Sifat-sifat Fisiko-kimia Pati Ubi Jalar, Ubi Kayu, Keladi, dan Sagu," *J. Ilmu Ternak dan Tanam.*, vol. 5, no. 1, pp. 37–42, 2015.

[17] N. L. G. S. Dewi, B. Admadi, and A. Hartiati, "Karakteristik bioplastik alginat dari rumput laut Ulva lactuca (tinjauan suhu dan lama gelatinisasi)," *J. Rekayasa Dan Manaj. Agroindustri*, vol. 5, no. 3, pp. 66–73, 2017.

[18] W. Setiani, T. Sudiarti, and L. Rahmidar, "Preparasi Dan Karakterisasi Edible Film Dari Poliblend Pati Sukun-Kitosan," *VALENSI*, vol. 3, no. 2, pp. 100–109, 2013, doi: 10.15408/jkv.v3i2.506.

[19] M. Afif, N. Wijayati, and S. Mursiti, "Pembuatan dan Karakterisasi Bioplastik dari Pati Biji Alpukat-Kitosan dengan Plasticizeafifr Sorbitol," *Indones. J. Chem. Sci.*, vol. 7, no. 2, pp. 102–109, 2018.