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## Characterization of Bioplastic from Rice Straw Cellulose.

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**ABSTRACT**

Rice straw (*Oryza sativa*) contain a fairly high cellulose. Cellulose is a natural biopolymer that can be used as a bioplastic material. This study aimed to investigate the characteristics of bioplastic that produce from a rice straw cellulose and to predict the potential utilization based on their characteristics. The production of bioplastic has been performance using phase inversion methods with a ratio of chitosan and cellulose pulp were 3:10, 4:10, and 5:10. The results showed that the bioplastics have different characteristics (water absorption, density, and the mechanical properties include tensile strength, elongation at break, and modulus of elasticity) depend on the ratio of chitosan and cellulose pulp. The utilization of this bioplastic can be customized according to their characteristics.
**Keywords:** cellulose, bioplastics, tensile strength, elongation at break, and modulus of elasticity

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## INTRODUCTION

Rice straw (*Oryza sativa*) is the stem of rice plants after the grains is harvested [1]. It is containing 37.71% of cellulose, 21.99% of hemicellulose, and 16.62 lignin [2]. A fairly high cellulose content is potential to be used as bioplastic material. Cellulose from rice straw is still not widely used. Mostly, rice straw becomes waste after the grain rice is taken. Cellulose is a biopolymer that can be produced from an agricultural product. The polymer agricultural product has thermoplastic properties that potential to be formed or molded into packaging films. The advantage of this polymer is renewable and biodegradable [3]. According to these properties, this polymer can be used as bioplastic, the plastic material that can be decomposed by microorganisms became an environmentally friendly compound [4].

Bioplastic technology is one of the ways to reduce the use of conventional plastic that has non-degradable properties and carcinogenic [5]. Bioplastic can be made from a fermentation process using bacteria or just mix the natural polymer with additional material to increase the properties of bioplastic [4,6]. Bioplastic is usually used as a plastic packaging, in addition, bioplastics are also potential to be used in a medical and pharmaceutical field like surgical thread, swabs, wound dressing, etc [7].

## MATERIAL AND METHODS

Materials used in this study are rice straw from Moh. Toha, Bandung, hydrochloride acid (Merck), sulphuric acid (Merck), aquadest, sodium hydroxide (Merck), acetic acid (Merck), glycerol, sodium hypochlorite, and chitosan (PT. Biotech Surindo). All of the reagents is used without further purification. Method that used in this research to fabrication of bioplastic is phase inversion methods.

## EXPERIMENTAL

The experiment consists of collected and determination of rice straw, preparation of rice straw, production of pulp, production of bioplastic and characteristic of bioplastic. All of this experiment is refers to the existing procedure to produce bioplastic [8].

## RESULT AND DISCUSSION

Rice straw (*Oryza sativa* L.) that used in this study is obtained from Moh. Toha, Bandung, Indonesia. It contains 22.07% cellulose and 3.48% lignin. This cellulose is isolated by pulping process to eliminate the lignin (delignification). In pulping process is also add the sodium hypochlorite as a bleaching agent to change the color of pulp from brown to white yellow.

The simple method that chosen for fabrication of bioplastic is phase inversion method with solvent casting technique. In this method, the polymer is dissolved in the solvent and the solvent was evaporated in the mold to get the bioplastic film layer [9]. The cellulose was added chitosan and glycerol in order to have a better physical and mechanical properties.

The bioplastics have a different characteristic depend on the composition of the ratio of chitosan and cellulose. Figure 1 showed the result of bioplastic from rice straw cellulose.

3:10 4:10 5:10

**Figure 1. Bioplastic from rice straw cellulose**

The part of characteristic was determined in the earlier paper [8]. In this paper will discuss another characteristic and combine all of characteristic that determine to know the physical and mechanical properties of bioplastic that resulted from this research.

The first parameter that measured is density. Density measurement of bioplastic is important because related with the characteristic of bioplastic to keep the product from the air. The result showed that the density of bioplastic with a ratio 3:10, 4:10, and 5:10 were 0.76 g/cm$^3$, 0.96 g/cm$^3$, and 1.14 g/cm$^3$, respectively. It was described that higher chitosan will produce a denser bioplastic. Chitosan will interact with cellulose by filling into the cavity between cellulose.

For the water absorption measurement is refers to the earliest paper [8]. The result showed that water absorption measurement is in line with the density measurement. The denser bioplastic has a smaller value of the percentage of water absorption. So, in this case, bioplastic with ratio chitosan and pulp 5:10 was the densest bioplastic with the smallest water absorption [8].

One of the important measurement to know the quality of plastic is mechanical properties determination. This determination includes tensile strength, elongation at break, and modulus of elasticity.

**Tensile strength** indicates the tensile strength of plastic that is generated when the plastic gets a load. The value of tensile strength describes the maximum of tensile strength to withstand the applied force [10]. The result of the tensile strength measurement can be seen in the earlier paper [8].

**Elongation at break**

This characteristic indicates the maximum strain of the material when the material is subjected to force. The value of elongation at break describes the percentage of elongation change of bioplastic when the material is stretched to break [15].

**Table 1. Determination of elongation at break on the bioplastic**

| No. | Bioplastic | % Elongation at break |
|---|---|---|
| 1. | 3 : 10 | 235.5 |
| 2. | 4 : 10 | 316.5 |
| 3. | 5 : 10 | 140.5 |

Table 1 showed that bioplastic 4:10 has the highest % elongation at break. The cavity of cellulose plays an important role in the elasticity [11]. The hydrogen interaction that occurs between the components of bioplastics will cause the cavity between the cellulose is filled with chitosan or glycerol. This can lead interaction between polymer chain will increase then will make the material more elastic as long as they formed polymer chain interaction [12]. Meanwhile, the elongation at break for bioplastic 5:10 was decreased. This condition may be due to of increased concentration of chitosan was not followed by the formation of the interaction with the polymer chains of bioplastics. The excess of chitosan cannot interact with the cellulose and glycerol because there are no free OH groups and all of cavity in the cellulose is fulfill with the glycerol and chitosan that have been added. This can affect the mechanical properties of bioplastic.

**Modulus of elasticity**

The modulus of elasticity is a measure of the stiffness of a material. Table 2 showed the result of measurement of modulus of elasticity. Bioplastic 4:10 has the highest modulus of elasticity compare to the others. The same reason with other mechanical properties, modulus of elasticity is also affected by interaction between bioplastic material.

**Table 2. Determination of modulus of elasticity on the bioplastic**

| No. | Bioplastic | Modulus of elasticity (MPa) |
|---|---|---|
| 1. | 3 : 10 | 1.8 |
| 2. | 4 : 10 | 10.5 |
| 3. | 5 : 10 | 2.6 |

Most of biodegradable plastic polymer are aliphatic polyester such as Poly Lactic Acid (PLA), Poly (ε-caprolactone) (PCL), Poly (ß-hydroxybutyrate) (PHB), and Poly Butylene Succinate Adipate (PBSA). All of this polymer has different characteristic. Table 3 showed the characteristic comparison of bioplastic research product, commercial bioplastic, and conventional bioplastic.

**Table 3. Characteristic of bioplastic and plastic [13,14].**

| Properties | Bioplastic | | | PLA | PCL | PBSA | PBAT | PP | PET |
|---|---|---|---|---|---|---|---|---|---|
| | 3:10 | 4:10 | 5:10 | | | | | | |
| Density (g/cm$^3$) | 0.76 | 0.956 | 1.139 | 1.25 | 1.11 | 1.23 | 1.21 | 0.90 | 1.37 |
| Water absorption (%) | 154.65 | 119.21 | 93.87 | 172 | 177 | 330 | 550 | 0.01 | 0.15 |
| Tensile strength (MPa) | 4.2 | 13.8 | 4.1 | | 14 | 19 | 9 | 24.7-302 | 45.52 |
| Elongation at break (%) | 235.5 | 316.5 | 140.5 | 9 | >500 | >500 | >500 | 21-220 | - |
| Modulus of Elastisity (MPa) | 1.8 | 10.5 | 2.6 | 2050 | 190 | 249 | 52 | 1430 | - |

PLA = Poly Lactic Acid
PCL = Poly (ε-caprolactone)
PBSA = Poly Butylene Succinate Adipate
PBAT = Poly(butylene adipate-co-terphthalate)
PP = Polypropylene
PET = Poly ethylene terphtalat

Based on the Table 3, most of biodegradable plastic has a higher water absorption compare to conventional plastic (PP and PET). The higher water absorption can make a plastic more easily degraded. We can combine the bioplastic and plastic to make a new one that has a better physical and mechanical properties.

## CONCLUSION

Bioplastic has different characteristic each other. The density value of bioplastics 3:10, 4:10, and 5:10 was 0.76, 0.956, and 1.139 g/cm$^3$, respectively. The determination of mechanical properties showed that bioplastics have the tensile strength was 4.2, 13.8, and 4.1 MPa; the elongation at break was 235.5, 316.5, and 140,5 %; and modulus of elasticity was 1.8, 10.5, and 2.6 MPa, for bioplastics 3:10, 4:10, and 5:10, respectively. This is a special characteristic that can develop the application of bioplastic or combine with conventional plastic to make a better biodegradable plastic.

## REFERENCES


[1] Komar, A. Teknologi Pengolahan Jerami Padi Sebagai Pakan Ternak. Bandung: Dian Grahita. 1984.

[2] Dewi. Hidrolisis Limbah Hasil Pertanian Secara Enzimatik. Akta Agrosia. 2002. No. 2, Vol. 5, pp. 67 – 71.

[3] Shofyan, Mohamad. Jenis Biopolimer. Available online at : http://forum.upi.edu/v3/index.php?topic=15650.0. 2010. [Accessed on: 12 February 2012].

[4] Sanjaya, I Gede dan T. Puspita. Pengaruh Penambahan Khitosan dan Plasticizer Gliserol pada Karakteristik Plastik Biodegradable dari Pati Limbah Kulit Singkong. Skripsi, Teknik Kimia FTI-ITS. 2011.

[5] Darni, Yuli., A. Chici, S. Ismiyati. Sintesa Bioplastik dari Pati Pisang dan Gelatin dengan Plasticizer Gliserol. Universitas Lampung, Seminar Nasional Sains dan Teknologi-II. 2008.

[6] Ningsih, Sri Widia. Pembuatan Bioplastik Polihidroksialkanoat Menggunakan Bakteri Mesofilik dan Media Limbah Cair Pabrik Kelapa Saawit. Tesis, FMIPA-USU. 2010.

ISSN: 0975-8585


[7] Kolybaba, M., L.G. Tabil, S. Panigrahi, W.J. Crerar, T.Powell, B. Wang. 2003. Biodegradable Polymers : Past, Present, and Future. Paper is presented in ASAE Annual Intersectional Meeting Sponsored by the Red River Section of ASAE, Quality Inn & Suites, 301 3rd Avenue North Fargo, North Dakota, USA, October 3-4, 2003.

[8] Rimadani P, et al. Pemanfaatan Selulosa dari Limbah Jerami Padi (Oryza sativa) sebagai bahan bioplastic. Indonesian Journal of Pharmaceutical Science and Technology, 2016. Vol. 3, No. 3.

[9] Porter, M.C. Handbook of industrial membrane technology. Noyes Publication. New Jersey. 1990.

[10] Surdia, T. dan S. Saito. Pengetahuan Bahan Teknik. PT Pradya Paramita, Jakarta. 1995.

[11] Kavitha, T., R. Padmashwini., A. Swarna., V.R. Giri Dev., R. Neelakandan. & M. Shentil Kumar. Effect of chitosan treatment on the properties of turmeric dyed cotton yarn. Indian Journal of Fiber & Textile Research . 2005. **32**: 53-56

[12] Juari. Pembuatan dan Karakterisasi Bioplastik dari Poly-3-Hidroksialkanoat (PHA) yang Dihasilkan Ralstonia Eutropha pada Hidrolisat Pati Sagu dengan Penambahan Dimetil Ftalat (DMF). Skripsi. Teknik pertanian. IPB. 2006.

[13] Averous, Pr. L. Bioplastic. Available online at http://www.biodeg.net/bioplastic.html .2008. [Accessed on: 23 June 2012].

[14] Pandey, A., P. Kumar, and V. Singh. Application of bioplastics in bulk packaging: a revolutionary and sustainable approach. Avaiable online at at: www.indiapackagingshow.com . 2010. [Accessed on: 12 February 2012].

[15] Datsko, J. Material Properties and Manufacturing Processes. John Wiley and Sons, New York. 1996.