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EFFECT OF OIL PALM SAP TAPPING AT THE PITH AND 50 CM FROM THE PITH ON THE CHARACTERISTICS OF PRODUCED BACTERIAL CELLULOSE

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Abstract
This study aims to utilize oil palm sap as a fermentation medium for bacterial cellulose production using Acetobacter xylinum bacteria. The study used a non-factorial Completely Randomized Design (CRD) consisting of two treatments, namely sap tapping from the apical meristem and sap tapping 50 cm from the apical meristem. Parameters observed included membrane thickness, dry weight, weight after distilled water immersion, absorption capacity, and tensile strength of bacterial cellulose membranes. The results showed that sap tapped from the apical meristem produced the highest membrane thickness of 15.8 mm compared to 11.7 mm for sap tapped 50 cm from the apical meristem. ANOVA analysis showed that the tapping treatment significantly affected membrane thickness and weight after distilled water immersion, but had no significant effect on dry weight and absorption capacity of bacterial cellulose. The highest absorption capacity was obtained in the apical meristem treatment at 3.68 g/g, while the 50 cm treatment showed 3.58 g/g. Tensile strength analysis showed that the 50 cm treatment had a higher max stress value of 17.138 MPa compared to 15.919 MPa in the apical meristem treatment, while the apical meristem treatment showed a higher elongation value of 4.110 mm. Based on the results, differences in oil palm sap tapping locations affected the physical and mechanical characteristics of the bacterial cellulose produced.

Keywords: Acetobacter xylinum, bacterial cellulose, oil palm sap.

INTRODUCTION

Oil palm is one of the leading plantation commodities in Indonesia that plays an important role in improving the national economy. According to Pardamean (2011), oil palm has high potential to be developed on both large-scale plantations and smallholder plantations due to its high productivity and greater resistance to cultivation constraints compared to other plantation crops. In addition, Mangoensoekarjo and Semangun (2008) stated that oil palm commodities provide extensive business opportunities, create employment, and improve community welfare. Oil palm is also the main source of vegetable oil processed into Crude Palm Oil (CPO) and Palm Kernel Oil (PKO) (Fauzi et al., 2012). So far, the most utilized part of the oil palm plant in industry is the fresh fruit bunches as raw material for palm oil production, while oil palm trunks from replanting activities are generally underutilized and often left to decay in plantation areas (Erwinsyah et al., 2015).

Replanting is one of the important stages in oil palm cultivation. Oil palm plants aged around 20–25 years experience a decline in productivity and therefore need to be replaced with more productive plants. According to Hartatik (2010), old oil palm plants that are not replanted will produce lower yields and become economically unprofitable. Replanting activities generate large amounts of biomass waste in the form of oil palm trunks, which may potentially pollute the environment if not properly utilized. One form of oil palm trunk waste utilization that has recently been developed is the extraction of palm sap as a raw material for fermentation products (Sahputra & Siregar, 2018). Palm sap is a sweet liquid obtained from felled and unproductive oil palm trunks (Barhami & Yunus, 2018). Chooklin et al. (2011) reported that palm sap contains high glucose levels reaching up to 86.9%. In addition, palm sap contains sucrose, fructose, galactose, amino acids, vitamins, and minerals that support microbial fermentation processes (Yamada et al., 2014). One felled oil palm trunk can produce approximately 10 liters of sap per day for about one month (Sulaiman et al., 2011). The high sugar content in palm sap makes it a potential carbon source for fermentation processes to produce various biotechnology products, one of which is bacterial cellulose. Palm sap tapping can be carried out using several methods, such as tapping from flower stalks or from felled oil palm trunks (Mulyani & Hidayat, 2019). According to Indraningtyas et al. (2019), different tapping methods may produce different sap volumes and qualities. Factors such as tapping duration, tapping location, and trunk conditions can affect sugar content, pH, moisture content, and nutrient composition of palm sap. The quality of the sap greatly determines the success of the fermentation process and the quality of the final product obtained.

Bacterial cellulose is a natural biopolymer produced by Acetobacter xylinum through the fermentation of liquid media containing carbohydrates (Iguchi et al., 2000). Bacterial cellulose appears as a white gel-like material commonly known as nata (Hestrin & Schramm, 1954). Ronggur et al. (2020) reported that bacterial cellulose has a nanofiber structure with high purity because it does not contain lignin and hemicellulose like plant cellulose. In addition, bacterial cellulose has high water absorption capacity, biocompatibility, biodegradability, and good mechanical strength, making it potentially applicable in various industrial fields such as food, pharmaceutical, medical, and environmentally friendly materials. The formation of bacterial cellulose is influenced by several factors, one of which is nutrient content in the fermentation medium. Adequate carbon sources support bacterial growth and optimal cellulose layer formation (Son et al., 2006). Common raw materials used for nata production include coconut water, pineapple juice, tofu waste, and cocoa waste (Nurhayati & Kusumaningrum, 2017). Besides these materials, palm sap also has potential as a fermentation medium because of its high sugar content and ease of fermentation by Acetobacter xylinum.

Different palm sap tapping methods are suspected to affect the characteristics of the bacterial cellulose produced. Differences in sap quality due to tapping methods may influence bacterial growth during fermentation, thereby affecting yield, moisture content, thickness, texture, and the physical and chemical quality of the bacterial cellulose formed. Therefore, research on the effect of palm sap tapping methods on bacterial cellulose characteristics is necessary to determine the best tapping method for producing high-quality bacterial cellulose. This study aims to evaluate the effect of palm sap tapping methods on the characteristics of bacterial cellulose produced. This research is expected to provide a sustainable solution for utilizing oil palm trunk waste through the development of palm sap-based bacterial cellulose products with added economic value and broad industrial application potential.The introduction includes background on issues or problems, urgency and rationalization of service activities. The activity objectives and problem-solving plans are presented in this section. Relevant literature reviews and analysis of specific situations for service are included in this section. The citation and citation model used in the article is APA Style. (Times New Roman, 12, normal).

LITERATURE REVIEW

Palm Sap

Palm sap is a liquid obtained from tapping oil palm trunks or flower stalks containing high levels of fermentable sugars. The main components of palm sap are glucose, sucrose, and fructose, which can be utilized as carbon sources for fermentative microorganisms (Chooklin et al., 2011). In addition to sugars, palm sap also contains minerals, vitamins, and amino acids that support microbial growth during fermentation (Yamada et al., 2014).

Bacterial Cellulose

Bacterial cellulose is a natural biopolymer produced by Acetobacter xylinum through extracellular biosynthesis (Iguchi et al., 2000). This cellulose has a nanofibril structure with high purity because it does not contain lignin or hemicellulose (Ronggur et al., 2020). Bacterial cellulose has high water absorption capacity, biodegradability, biocompatibility, and good mechanical properties, making it suitable for applications in food, medical, pharmaceutical, and environmentally friendly material industries.

Factors Affecting Bacterial Cellulose Formation

Bacterial cellulose production is influenced by several factors such as nutrient content, fermentation temperature, pH, carbon source, and incubation time (Son et al., 2006). Adequate carbon availability can increase bacterial activity in forming cellulose networks. In addition, fermentation media quality also determines the thickness, fibril structure, and mechanical properties of the bacterial cellulose membrane produced.

METHOD

Research Design

This study was conducted for eight months from June 2025 to March 2026. The research used a non-factorial Completely Randomized Design (CRD) consisting of two treatments and four replications, resulting in eight experimental units.

The treatments consisted of:

1. P1 = Palm sap tapping from the pith.
2. P2 = Palm sap tapping 50 cm from the pith.

The observed parameters included bacterial cellulose membrane thickness, absorption capacity, and tensile strength.

Materials and Equipment

The materials used included palm sap, Acetobacter xylinum starter culture, sucrose, 98% acetic acid, 0.1 N NaOH solution, distilled water, and buffer solutions.

The equipment used included machetes, collection containers, fermentation trays, measuring cylinders, analytical balances, pH meters, ovens, fermentation incubators, digital calipers, Universal Testing Machine (UTM), Scanning Electron Microscopy (SEM), X-Ray Diffraction (XRD), and Fourier Transform Infrared Spectroscopy (FTIR).

Research Procedure

Palm Sap Tapping

Non-productive oil palm trees aged more than 20 years were selected as the sap source. Tapping was conducted at the pith and 50 cm from the pith. The oil palm trunks were cleaned and wilted for 3–7 days before scraping the surface to obtain the sap. The collected sap was filtered and pasteurized before being used as fermentation media.

Bacterial Cellulose Production

Palm sap was inoculated with Acetobacter xylinum starter culture and incubated statically at 30°C for 7–10 days. The bacterial cellulose formed was separated from the fermentation medium, washed with distilled water, and soaked in 0.1 N NaOH solution at 80°C for 1 hour. After reaching neutral pH, the cellulose was dried in an oven at 60°C until constant weight was achieved.

Measurement of Cellulose Thickness

The thickness of the bacterial cellulose membrane was measured using a digital caliper with an accuracy of 0.05 mm at several points on the sample surface, and the average value was calculated.

RESULTS AND DISCUSSION

Bacterial Cellulose Thickness

The average thickness of bacterial cellulose membranes from the pith tapping treatment was 15.8 mm, while the treatment 50 cm from the pith produced an average thickness of 11.7 mm. The pith treatment produced thicker membranes compared to the 50 cm treatment.

The difference in membrane thickness was presumably influenced by sugar and nutrient content in the palm sap used as fermentation media. Higher carbon source availability increases bacterial cellulose biosynthesis activity, resulting in thicker membrane formation (Mishra et al., 2018). In addition, Putri et al. (2020) reported that increased nutrient availability during fermentation significantly increased bacterial cellulose thickness.

Table 1. ANOVA Results of Bacterial Cellulose Thickness

Source of Variation	Sum of Squares	DF	Mean Square	F-value	Sig.
Between Groups	34.861	1	34.861	66.455	0.000
Within Groups	3.148	6	0.525		
Total	38.009	7			

The analysis results showed a significance value lower than 0.05, indicating that palm sap tapping treatment significantly affected bacterial cellulose membrane thickness.

Bacterial Cellulose Absorption Capacity

The average absorption capacity of bacterial cellulose membranes from the pith treatment was 3.68 g/g, while the treatment 50 cm from the pith showed 3.58 g/g. Numerically, the pith treatment exhibited higher absorption capacity. The difference in absorption capacity was presumably related to pore structure and fibril arrangement formed during fermentation. More porous fibril structures allow greater water absorption into the membrane network (Jankau et al., 2018). However, ANOVA results indicated that the difference between treatments was not statistically significant.

Bacterial Cellulose Tensile Strength

The pith tapping treatment produced a maximum stress value of 15.919 MPa and elongation of 4.110 mm. Meanwhile, the treatment 50 cm from the pith produced a maximum stress value of 17.138 MPa and elongation of 1.612 mm. These results indicate that membranes produced from the 50 cm treatment had better tensile resistance, while the pith treatment produced more flexible membranes. These mechanical property differences were presumably influenced by the microfibril structure formed during fermentation.

CONCLUSION

Based on the results of this study, palm sap tapped from both the pith and 50 cm from the pith can be used as an alternative substrate for bacterial cellulose production. Differences in tapping location affected the characteristics of the bacterial cellulose produced. The pith treatment produced membranes with greater thickness of 15.8 mm, absorption capacity of 3.68 g/g, and elongation of 4.110 mm, indicating better flexibility. Meanwhile, the treatment 50 cm from the pith produced a higher maximum stress value of 17.138 MPa, indicating better mechanical strength. Overall, the pith tapping treatment showed more optimum characteristics in terms of membrane thickness, water retention ability, and material flexibility.

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REFERENCES

Pardamean, M. Sukses Membuka Kebun dan Pabrik Kelapa Sawit. Jakarta: Penebar Swadaya, 2011.

Mangoensoekarjo, S., dan Semangun, H. Manajemen Agrobisnis Kelapa Sawit. Yogyakarta: Gadjah Mada University Press, 2008.

Fauzi, Y., Widyastuti, Y. E., Satyawibawa, I., dan Hartono, R. Kelapa Sawit: Budidaya, Pemanfaatan Hasil dan Limbah, Analisis Usaha dan Pemasaran. Jakarta: Penebar Swadaya, 2012.

Erwinsyah, Sugesty, S., dan Kardiansyah, T. “Pemanfaatan Batang Kelapa Sawit Sebagai Bahan Baku Produk Bernilai Tambah,” Jurnal Selulosa, vol. 5, no. 2, pp. 75–84, 2015.

Hartatik, W. “Teknologi Peremajaan Kelapa Sawit untuk Meningkatkan Produktivitas,” Jurnal Litbang Pertanian, vol. 29, no. 4, pp. 145–152, 2010.

Sahputra, A., dan Siregar, H. “Pemanfaatan Nira Batang Kelapa Sawit pada Produk Fermentasi,” Jurnal Teknologi Agroindustri, vol. 9, no. 1, pp. 23–30, 2018.

Barhami, S., dan Yunus, M. “Karakteristik Nira Sawit sebagai Media Fermentasi,” Jurnal Rekayasa Pangan dan Pertanian, vol. 6, no. 3, pp. 455–462, 2018.

Chooklin, S., Kaewsrichan, J., dan Maneerat, S. “Potential Utilization of Oil Palm Sap Through Fermentation,” Songklanakarin Journal of Science and Technology, vol. 33, no. 2, pp. 173–180, 2011.

Yamada, H., Tanaka, R., dan Sulaiman, O. “Chemical Composition and Fermentation Characteristics of Oil Palm Sap,” International Food Research Journal, vol. 21, no. 2, pp. 561–567, 2014.

Sulaiman, O., Salim, N., dan Nordin, N. “Yield and Quality of Oil Palm Trunk Sap for Fermentation Applications,” Bioresource Technology, vol. 102, no. 19, pp. 9076–9081, 2011.

Mulyani, D., dan Hidayat, T. “Teknik Penyadapan Nira Kelapa Sawit pada Batang dan Tangkai Bunga,” Jurnal Agribisnis Perkebunan, vol. 14, no. 1, pp. 35–42, 2019.

Indraningtyas, A. A., Hastuti, P., dan Santosa, B. “Pengaruh Metode Penyadapan terhadap Karakteristik Nira Sawit,” Jurnal Teknologi dan Industri Pangan, vol. 30, no. 2, pp. 110–118, 2019.

Iguchi, M., Yamanaka, S., dan Budhiono, A. “Bacterial Cellulose—A Masterpiece of Nature’s Arts,” Journal of Materials Science, vol. 35, no. 2, pp. 261–270, 2000.

Hestrin, S., dan Schramm, M. "Synthesis of Cellulose by Acetobacter xylinum," Biochemical Journal, vol. 58, no. 2, pp. 345–352, 1954.

Ronggur, H., Situmorang, M., dan Simanjuntak, P. "Karakteristik Selulosa Bakteri sebagai Biomaterial Ramah Lingkungan," Jurnal Kimia Mulawarman, vol. 18, no. 1, pp. 12–19, 2020.

Son, H. J., Heo, M. S., Kim, Y. G., dan Lee, S. J. "Optimization of Fermentation Conditions for Bacterial Cellulose Production," Bioresource Technology, vol. 97, no. 6, pp. 734–739, 2006.

Nurhayati, T., dan Kusumaningrum, H. "Pemanfaatan Limbah Pertanian sebagai Media Produksi Nata," Jurnal Pangan dan Agroindustri, vol. 5, no. 3, pp. 45–53, 2017.

Mishra, R., Sabu, A., dan Tiwari, S. K. "Materials Chemistry and the Futuristic Applications of Bacterial Cellulose," Nano-Micro Letters, vol. 10, no. 2, pp. 1–22, 2018.

Putri, D. A., Lestari, P., dan Rahman, F. "Pengaruh Nutrisi Fermentasi terhadap Karakteristik Selulosa Bakteri," Jurnal Teknologi Hasil Pertanian, vol. 13, no. 2, pp. 89–97, 2020.

Jankau, J., Pietrucha, K., dan Oledzka, E. "Water Holding Capacity and Porosity of Bacterial Cellulose Biomaterials," Carbohydrate Polymers, vol. 189, pp. 148–156, 2018.

Nur, S., Wahyuni, D., dan Harahap, F. "Karakteristik Penyerapan Air Selulosa Bakteri Berbasis Nira Sawit," Jurnal Rekayasa Biosistem, vol. 15, no. 1, pp. 55–63, 2021.