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The effect of microwave treatment on the color changes and wettability of sembilang bamboo (*Dendrocalamus giganteus Munro*)

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ABSTRACT

Bamboo has the potential to be a substitute for wood, although it is no exception that bamboo has many weaknesses. Bamboo is a plant with fast growth, short recycling times, and the potential to be used as structural and non-structural materials. Sembilang bamboo is a bamboo that has a large diameter and is commonly known as giant bamboo. Poor adhesive dispersion was a problem in previous studies, and the presence of discoloration due to important treatments was known. Heating using a microwave is a step in this research to solve the problems that occur. The research was carried out by measuring bamboo samples of a certain size, then the bamboo was scanned, and the wettability was measured initially and at the end of the test. Bamboo samples were heated in the microwave at temperature of 60–75°C for 0.5–1 min. The results of the 1 min and 0.5 min microwave treatment tests can increase wettability lead to the spread becomes longer, with a small K value of 0.391. This is presumably because the contact angle is less than 90°. In addition, the treatment also had a small and moderate effect on the color differences that occurred.

Keyword: Sembilang bamboo, microwave treatment, wettability, and color differences

INTRODUCTION

The increasing use of round wood which is not supported by the availability of raw materials will give rise to new problems and challenges. According to KLHK data (2022), the amount of log production in Indonesia's natural forests continues to increase, namely by 5.27 million (2020); 6.05 million (2021). However, what is becoming a greater worry is how to sustain the amount of logs. So that the use of logs must be replaced by other structural materials. Bamboo is the right type of plant to substitute for materials such as wood because bamboo has many benefits, ranging from construction materials to furniture, pulp raw materials, and so on. Bamboo a plant with fast growth, a short cycle, abundant potential, and is easy to plant, it is also used as a building material (Febrianto et al., 2017). Bamboo plants live in clumps and are widespread throughout Indonesia, usually found in riverbanks or moor areas. The types of bamboo in Indonesia are very diverse, with as many as 161 species (Widjaja et al., 2014).

Sembilang bamboo is a bamboo that has a large diameter and is commonly known as giant bamboo. This bamboo comes from the regions of Myanmar, Thailand, and China (Prosea, 1995). However, bamboo has a weakness in spreading adhesive (wettability) due to the fibers are not neat and peel off easily. Wettability is the ability of a liquid to spread and penetrate a material surface. The wettability of wood can be obtained by measuring the contact angle between the applied liquid droplets and the wood surface (Yuan & Lee, 2013). Microwave treatment has the potential to change the physical and chemical properties of the bamboo material, including changes in color and wettability (the surface's ability to absorb or repel water). The effect of microwave treatment on the discoloration of the Sembilang Bamboo can be caused by changes in the chemical structure and chemical components of the bamboo. Meanwhile, the effect on wettability can occur due to changes in the microscopic structure of the bamboo surface and the redistribution of chemical components. In several studies, phenolic compounds in extractive substances were related to wood color in several species (Burtin et al., 2000). Microwave have the ability to affect how hard and colored wood changes. Heat waves are regarded as an environmentally benign technique due to their low reliance on chemical ingredients (Widyorini *et al*., 2014)

More detailed information about the mechanism of change and optimal parameters in microwave treatment can assist in the development of of more effective and efficient technigues in modifying the properties of sembilang bamboos. Thus, this study aims to investigate the effect of microwave treatment on the change in color and wettability of the nine bamboos. It is hoped that this research can provide a deeper understanding of the mechanical processes involved as well as contribute to the development of better treatment technique to modify the properties of sembilang bamboos.

METHODS

Research Tools and Material

This research used microwave oven, cutter, scanning machine, laptop, oven, contact angle measuring device, and caliper. While the material used is Sembilang bamboos (Dendrocalamus giganteus Munro) at the base.

Research Prosedure

The raw material used was Sembilang Bamboo (*D. giganteus* Munro) at the base with dimensions of 2 x 1 x 10 cm (width x thickness x length) with 2 treatments (3 replications), so there were 6 samples. The bamboo is taken on the same side of the sample. Before being given treatment, each sample was scanned to see the color changes that occurred in the bamboo after being given the treatment. After the scanning is complete, water drips using a micropipette on the surface of the bamboo sample, and the drops are recorded (video or photo) using a laptop with a 40x magnification macro lens until the water runs out.

Samples were heated using microwaves for several repetitions. The first 3 samples of Sembilang Bamboo were given a microwave heating treatment at a constant temperature for 1 min, then 5 mins of rest, and repeated 3 times. The second treatment was the microwave heating treatment at a constant temperature for 0.5 mins, then rested for 5 mins, and then repeated the same six time. Following the heat treatment, the test samples were treated to a conditioning process by heating them in an oven at a temperature of 60ºC.

Then repeat with another drip of water using a micropipette on the surface of the bamboo sample. The drops are recorded (video or photo) using a laptop with a 40x macro lens until the water time runs out. The data in video form is then processed using GOM video to get photos every 2 seconds since the water is dripping. After obtaining the photo, the data is processed to measure the contact angle using ImageJ.

Data Analisys

Color Change Testing

Wood color measurements were carried out using a Canon MP 145 scanner connected to a laptop as data storage and processed using Adobe Photoshop 7, which will produce L* (brightness), a*, and b* values (Burtin et al., 2000). Then the color difference (ΔE) is calculated according to the formula:

$$\Delta E = \sqrt{[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]}$$

Remarks:
ΔE : Color difference
ΔL* : Brightness difference (L* before treatment- L* after treatment)
Δa* : Red or green difference (a* before treatment - a* after treatment)
Δb* : Yellow or blue difference (b* before treatment - b* after treatment).

Table 1. Effect of Difference Color Value ΔE (Burtin *et al.*, 2000)

Color Difference ΔE	Effect
< 0.2	Invisible
0.2 - 1.0	Very Small
1.0 - 3.0	Small
3.0 - 6.0	Moderate
> 6.0	Large

Wettability Testing

Data in the form of video in WMA format is then analyzed with the Gom Player software to obtain image segments every 2 seconds. Furthermore, the contact angle is obtained with the angle measurement facility of the ImageJ software. The value of the contact angle is determined based on the polynomial regression equation between time (x) and contact angle (y) at time x = 0. The general form of the regression equation is y = ax2 + bx + c (a, b, and c are regression constants)

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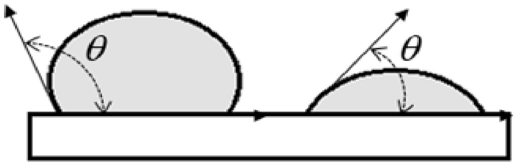

Figure 1. Contact angle measurement (θ)

The constant contact angle value was determined based on the segmented regression equation between time (t) and contact angle (θ) using the PROC CLIN program from SAS Furthermore, the value of the K parameter is determined based on the S/G model (Shi & Gardener, 2001). The S/G model uses the formula equation 1:

$$\theta = \frac{\theta i.\ \theta e}{\theta i + (\theta e - \theta i)[Kt\left(\frac{\theta e}{\theta e - \theta i}\right)]}$$

Remarks:
θ : Contact angle at any given time
θi : First contact angle
θe : Equilibrium contact angle
T : Time
K : Constant rate of change of contact angle
The K value of the S/G model is searched using the XLSTAT 2019 program

RESULT AND DISCUSSION

Bamboo Color Difference

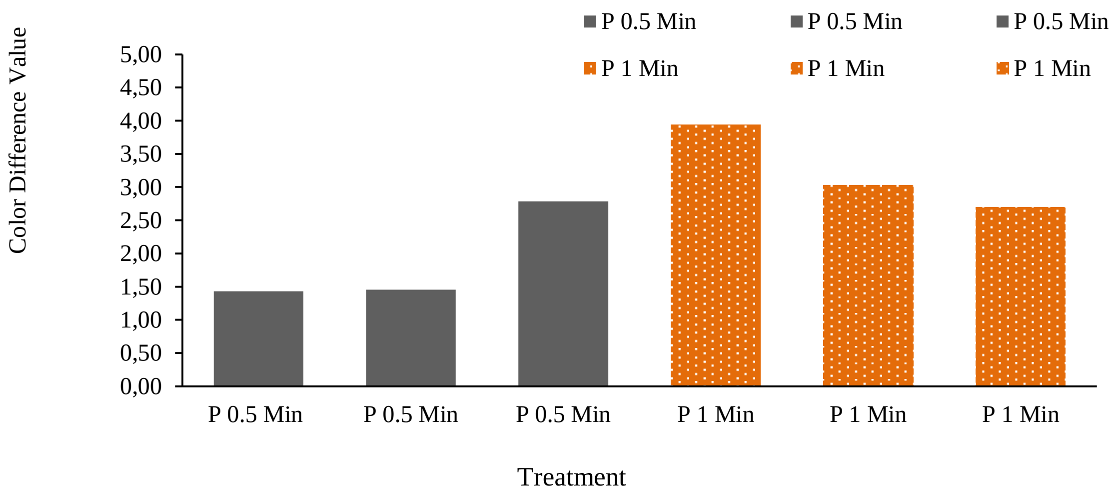

Figure 2. Graph of Color Difference (E) in various treatments 0.5 min microwave treatment (P0.5) and 1 min microwave treatment (P1).

Color provides characteristics for various types and is very dependent on the extractive substances it contains, although it is usually difficult to express it in words. It does not consist of just one color but a mix of various types of colors. The test results through the color difference values can be seen in the graph of the color difference values for the 0.5 min microwave treatment with three repetitions each having a value of 1.428, 1.456, and 2.786. If this value is accumulated to become an average, a value of 1.890 will be obtained. This is entered into the table of the effect of differences in color values, and the result will be obtained, which has a "small" effect on color changes. Ideally, in this study, it would have a moderate color change, but due to the condition of the material (bamboo), it has a higher water content and extractive substances that have been degraded by air drying.

Treatment in the microwave for 1 min showed a color difference with a value of 3.945, 3.027, and 2.698, with an average of 3.223. If this value is included in the table for the effect of differences in color values, the result will be obtained, which has a "moderate" effect. It is hypothesized that the material will undergo excessive heating and extractive ingredient degradation with prolonged heating, resulting in a darker color. (Burtin et al., 2000). According to Muflihati et al., (2014) the greater and more positive the L* value, the higher the brightness; on the other hand, the lower the L* value, the darker the color. This is supported by research results that show a decrease in the value of L*.

Contact Angle

One of the criteria that can be used to analyze the wettability of wood with liquids is the measurement of the contact angle. According to several studies, this contact angle is influenced by the surface roughness of the material or materials used (Cahyono, 2017) and surface cleanliness (Lestari et al., 2016). Hse (1972) asserts that although there have been numerous research on solid content, the contact angle is closely linked to the adhesive bond's quality rather than having anything to do with SC.

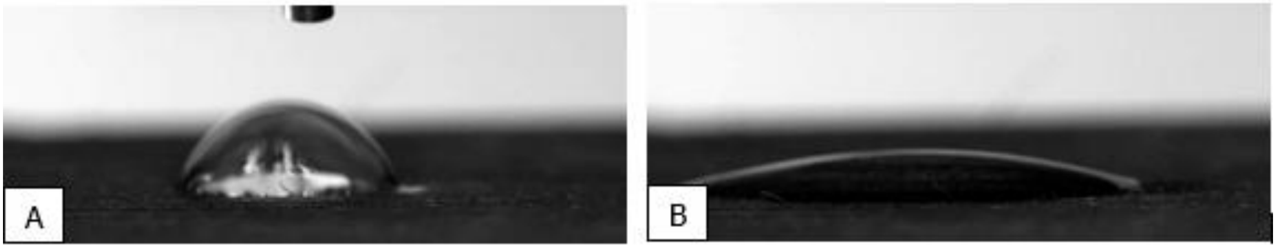

Figure 3. Example of measuring the contact angle on the SDP2 sample that has the highest initial value: Seconds 0 (Image A) and Seconds 12 (Image B).

In this study, the resulting contact angle did not exceed 90°; this shows that the wettability was quite good in the bamboo samples, which were given 0.5 and 1 min microwave treatments, respectively. I agree with this; according to Yuan & Lee (2013), the value of the contact angle when it is above 90° indicates poor wettability. The higher the contact angle, the lower the wettability will be. The implication is that it will be difficult for liquids to wet the surface. According to Laskowska & Kozakiewicz (2017), the direct contact angle is also influential due to the content of extractive substances that can hold the wettability itself; besides, the skin part of the bamboo has many vascular bundles compared to the inside, so the absorption of wettability is good (Ying, 1996). The contact angle can be seen in the graph below.

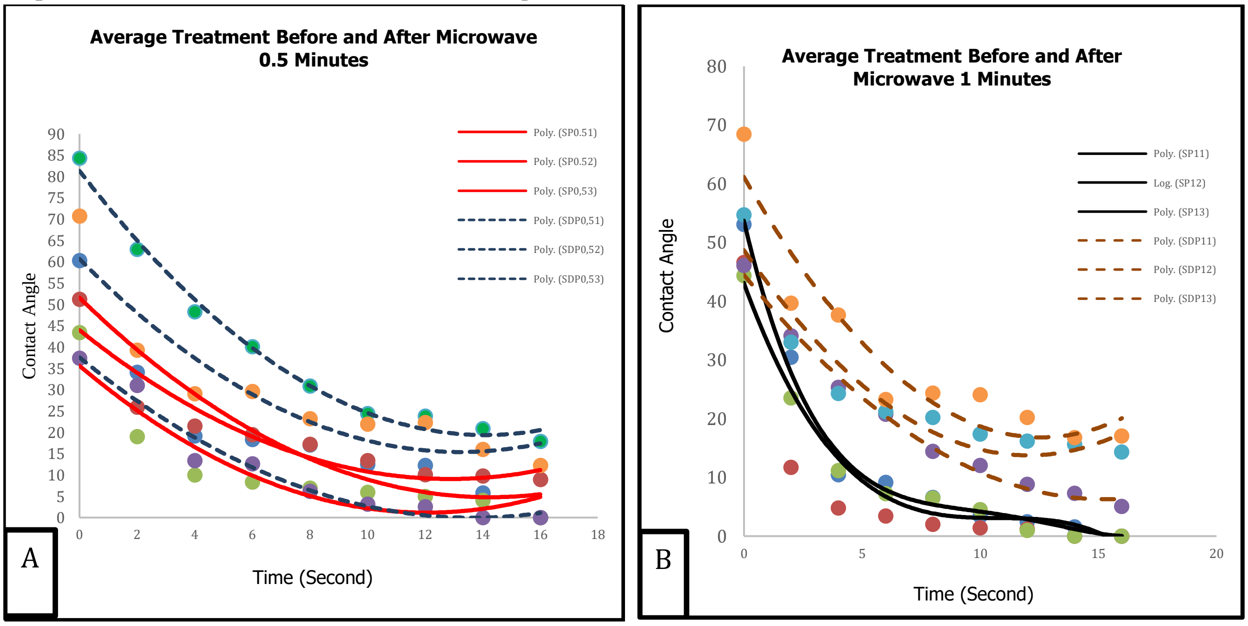

Figure 4. Graph of average contact angle values based on 0.5 min and 1 min microwave treatments: 0.5 microwave treatment (picture A) and 1 microwave treatment (picture B).

The graph above shows that there was a drastic change in the contact angle from the beginning of the observation to the next observation. It is presumed that the bamboo sample has a lot of roughness and fiber on the surface. According to Tang et al., (2012), the slope of the contact angle change curve based on the time function is closely related to the viscosity as well as surface properties. In more detail, the slope of the curve in the following explanation will be complemented by the percentage reduction in the contact angle and the value of K.

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Wettability

The wettability of wood is an important parameter that provides a range of information about the interactions between wood surfaces and fluids such as water, coatings and adhesives. Furthermore, the value is close to the equilibrium contact angle and is denoted θe (Lu & Wu, 2006). The equilibrium contact angle is obtained from non-linear regression using equation 1. Next, from this equation, the K value is also obtained, which is an indicator of the speed of the surface wetting process by liquid (Table 2). The closeness of the relationship between the parameters used in determining the value of K is shown from the value of the correlation coefficient above 0.90 and the standard error (SE) is not more than 12% compared to the value of K. Therefore Thus, the precision of the wetting process on different wood surfaces in this investigation may be explained by the wetting model. The value of K is a constant indicating the speed of reduction of the contact angle.

Table 2. Dynamic wettability (K) for various types of woodworking samama (R = correlation coefficient, θe = equilibrium contact angle, θi = contact angle at the first drip).

Code Sample	θe	θi	K	R^2	Decline (%)
SP0,51	10.089	60.297	0.589	0.92	83.266
SP0,52	12.525	51.16	0.547	0.958	75.517
SP0,53	5.154	43.377	0.967	0.964	88.117
SP11	3.213	53.083	0.804	0.926	93.947
SP12	1.858	46.632	2.243	0.985	96.015
SP13	2.692	44.357	0.802	0.937	93.930
SDP0,51	0.875	37.381	0.426	0.855	97.658
SDP0,52	20.675	84.284	0.268	0.947	75.469
SDP0,53	21.045	70.676	0.520	0.944	70.222
SDP11	6.523	46.138	0.295	0.93	85.862
SDP12	17.278	54.759	0.460	0.981	68.447
SDP13	20.561	68.467	0.418	0.952	69.968

The wettability used in this sample is distilled water which has a low viscosity. Wettability is very influential with the viscosity of the liquid / liquid. Agree with this according to Monni et al., (2007) The wettability of the surface of the material decreases with the high value of the viscosity of the liquid.

From the table above it can be seen that the highest K was for before the microwave treatment 1 min repeat 2 (SP12) with a K value of 2.243 while the lowest was on the surface of the sample after the microwave treatment for the first 1 min repetition (SDP11). This is also the same as the surface before treatment with repetition 3 (SP0.53) with a K value of 0.967. Table 2 shows that the lowest K value was found in the 1 min microwave heating treatment with an average K value of 0.391. According to Cahyono (2017) the greater the K value indicates that the wetting process requires a shorter time. In this study, it is suspected that the longer the heating treatment using a microwave for a certain time will make the wettability longer in spreading and absorbing it.

This is in accordance with the result oe research by Wang & Cooper (2005) heating media will reduce the process of water absorption when it is dropped on the sample. Research by T Li et al., (2015) revealed that the treatment process by heating with oil will have a negative impact on the wettability of the bamboo surface. In line with this according to Hakkou et al., (2005) suggested that modification of the conformational arrangement of the bamboo component would be the reason for the change in wettability. In this study it can be taken the statement that the heating treatment will affect the wettability of the bamboo.

REFERENCE

Burtin P, Jay-Allenand C, Charpentier JP and Janin G. 2000. Modification of hybrid walnut (*Juglans nigra* 23 x *Juglans regia*) wood colour and phenolic composition under various steaming condition. Holzforschung 54(1): 33-38. https://doi.org/10.1515/HF.2000.006

Cahyono TD, Wahyudi I, Priadi T, Febrianto F, and Ohorella S. 2017. Sudut Kontak dan Keterbasahan Dinamis Kayu Samama pada Berbagai Pengerjaan Kayu. *Jurnal Teknik Sipil* 24(3): 209-216. https://doi.org/10.5614/jts.2017.24.3.3

Febrianto F, Sumardi I, Hidayat W, Maulana S. 2017. *Papan Untai Bambu Berarah Material Unggul Untuk Komponen Bangunan Struktur*. IPB Press, Bogor (ID), p. 159.

Hakkou M, Pétrissans M, Zoulalian A, Gerardin P. 2005. Investigation of wood wettability changes during heat treatment on the basis of chemical analysis. *Polym. Degrad. Stabil.* 89 (1): 1–5. https://doi.org/10.1016/j.polymdegradstab.2004.10.017

Hse CY. 1972. Wettability of southern pine by phenol formaldehyde wood adhesive. *Forest Product Journal* 22(1): 51-56. https://www.fs.usda.gov/research/treesearch/24148. 03 Agustus 2023.

Kementerian Lingkungan Hidup dan Kehutanan. 2022. *Statistik Direktorat Jendral PLH*. Jakarta (ID). Kementerian Lingkungan Hidup dan Kehutanan. Indonesia.

Laskowska A and Kozakiewicz P. 2017. Surface wettability of wood species from tropical and temperate zones by polar and dispersive liquids. *Drvna Industrija* 68(4): 299-306. https://doi.org/10.5552/drind.2017.1704

Lestari AT, Darmawan iw, dan Nandika D. 2016. Pengaruh Kondisi Permukaan terhadap Daya Lekat Lapisan Pelindung. *J. Ilmu Teknol. Kayu Tropis* 14(1): 11-22. https://doi.org/10.51850/jitkt.v14i1.7.g7

Lu JZ and Wu Q. 2006. Surface Characterization of Chemically Modified Wood: Dynamic Wettability. *Wood and Fiber Science,* 38(3):497-511. https://wfs.swst.org/index.php/wfs/article/view/1488. 03 Agustus 2023.

Monni J, Alvila L, Pakkanen TT. 2007. Structural and physical changes in phenol-formaldehyde resol resin, as a function of the degree of condensation of the resol solution. *Industrial & Engineering Chemistry Research* 46(21):6916-6924. https://doi.org/10.1021/ie070297a

Muflihati, Nawawi DS, Rahayu IS, and Syafii. 2014. Perubahan Warna Kayu Jabon Terwarnai Ekstrak Kulit Kayu Samak (Syzygium inophyllum). *J. Ilmu dan Teknologi Kayu Tropis* 12(1): 11-19. https://doi.org/10.51850/jitkt.v12i1 Prosea. 1995. *Plant Resources of South-East Asia 7. Bamboos*. Prosea Foundation, Bogor (ID).

Shi SQ and Gardner DJ. 2001. Dynamic adhesive wettability of wood. *Wood and Fiber Science* 33(1):58-68. https://wfs.swst.org/index.php/wfs/article/view/538. 03 Agustus 2023.

Tang L, Zhang R, Zhou X, Pan M, Chen M, Yang X, Zhou P, and Chen Z. 2012. Dynamic adhesive wettability of poplar veneer with cold oxygen plasma treatment. *BioResources*, 7(3):3327-3339. https://doi.org/10.15376/biores.7.3.3327-3339

T Li, Chenga D-l, Magnus EP, Walinder B, and Zhoua DG. 2015. Wettability of oil heat-treated bamboo and bonding strength of laminated bamboo board. *Industrial Crops and* Products 69: 15–20. https://doi.org/10.1016/j.indcrop.2015.02.008

Wang JY and Cooper PA. 2005. Effect of oil type: temperature and time on moisture properties of hot oil-treated wood. *Holz Roh Werkst*. 63: 417–422. https://doi.org/10.1007/s00107-005-0033-4

Widjaja EA, Rahayuningsih Y, Ubaidillah R, Maryanto I, dan Rahajoe JS. 2014. Kekinian keanekaragaman hayati Indonesia 2014. LIPI Press, Jakarta (ID), p.344

Widyorini R, Khotimah K, Prayitno TA. 2014. Pengaruh suhu dan metode perlakuan panas terhadap sifat fisika dan kualitas finishing kayu mahoni. *Jurnal Ilmu Kehutanan* 8(2): 65-75. https://doi.org/10.22146/jik.10160

Ying SC. 1996. *Wood Science*. China Forestry Publishing House. Beijing, China. https://www.abebooks.com/Wood-Science-2Chinese-Edition-LIU-XING/10565739862/bd. 03 Agustus 2023.

Yuan Y and Lee TR. 2013. Contact angle and wetting properties, Surface Science Techniques. *Springer***:** 3-34. https://link.springer.com/chapter/10.1007/978-3-642-34243-1_1. 03 Agustus 2023.