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ОПРЕДЕЛЕНИЕ ИЗМЕНЕНИЙ, ВЫЗВАННЫХ ХИМИЧЕСКИМИ ОТБЕЛИВАТЕЛЯМИ ДРЕВЕСИНЫ В ДЕРЕВЕ МЕНГКУЛАНГ (*HERITIERA JAVANICA* (BLUME) KOSTERM.)

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Аннотация. Исследование направлено на определение изменений поверхностных свойств, вызванных использованием отбеливающих химикатов на древесине менгкуланг (*Heritiera javanica* (Blume) Kosterm.). С этой целью была создана контрольная группа, на поверхности древесины которой были нанесены химикаты оксаловая кислота ($C_2H_2O_4$) и перекись водорода (H_2O_2) + гидроксид натрия (NaOH), после чего были произведены измерения цвета, блеска и индекса белизны (*WI**). Согласно полученным результатам, значения измерений блеска, проведенных на волокнах ‖ и ⊥ 20°, оказались незначительными, в то время как все остальные тесты были признаны значимыми. Значения ΔE^* составили 3,73 для отбеливания $C_2H_2O_4$ и 13,81 для отбеливания H_2O_2 + NaOH. С обоими отбеливающими веществами были отмечены увеличения значений *WI**, *b**, *L**, *C** и *h*° в обоих направлениях, в то время как уменьшения были определены в значениях блеска при 60 и 85°.

Ключевые слова: отбеливание, глянец, мангкуланг, цвет, херитиера яванская, индекс белизны
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Original article

DETERMINATION OF CHANGES CAUSED BY WOOD BLEACHING CHEMICALS IN MENGKULANG (*HERITIERA JAVANICA* (BLUME) KOSTERM.)

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Abstract. This study aimed to determine the changes in certain surface properties caused by the use of wood bleaching chemicals on Mengkulang (*Heritiera javanica* (Blume) Kosterm.) timber. For this purpose, a control group was established, and oxalic acid ($C_2H_2O_4$) and hydrogen peroxide (H_2O_2) + sodium hydroxide (NaOH) chemicals were applied to the wood material surfaces, followed by measurements of color, glossiness, and whiteness index (*WI**) properties. According to the obtained results, values for glossiness test measurements conducted on fibers ‖ and ⊥ 20° were found to be insignificant, while all other tests were determined to be significant. The Δ*E** values were calculated as 3,73 for $C_2H_2O_4$ bleaching and 13,81 for H_2O_2 + NaOH bleaching. With both bleaching agents, increases were observed in *WI**, *b**, *L**, *C**, and ho values in both directions, while decreases were determined in glossiness values at 60 and 85 degrees.

Keywords: Bleaching, glossiness, mengkulang, color, Heritiera javanica, whiteness index

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Introduction

Mature wood is a natural amalgamation of elongated cells lacking biological function, commonly recognized as wood fibers, forming an organic composite material. The cellular structures of these fibers are primarily composed of cellulose fibrils (40–50 %), characterized by a predominantly crystalline arrangement, ensconced within an amorphous framework comprising hemicellulose (20–35 %) and lignin (20–30 %). Additionally, wood encompasses varied proportions of non-structural organic compounds of low molecular weight, termed extractives, along with mineral constituents (ash). Lignin is notably concentrated in the outermost layer of the cell wall (middle lamella), playing a pivotal role in bonding the fibers together within the wood (Sjöström, 1981; Wood…, 1984; Pinto et al., 2005).

Color fading occurs both indoors and outdoors. Many factors and elements contribute to the fading of wood color (Hon and Minemura, 2000). Bleaching is also used to alter the properties of wood surfaces before finishing and to reduce yellowing caused by light (Chemical treatment…, 1995; Finishing properties of poly…, 2021).

When using alkaline bleaches, especially when caustic is part of the process, it is usually necessary to neutralize the wood's surface before further finishing with varnish or lacquers (Zeilman, 1960).

As a result of chemical treatments, the quantity of covalent bonds within cellulose, hemicellulose, and lignin diminishes. This reduction in covalent bonds correlates with a lightening of the wood's color. Various bleaching agents, notably hydrogen peroxide, and occasionally oxalic acid, sodium hypochlorite, and sodium bisulfite, are commonly employed for this purpose (Forest Products Laboratory…, 1967; Csiha and Papp, 2013).

The Mengkulang – palapi (*Heritiera javanica*) tree species belongs to the genus Heritiera in the Malvaceae family (Laraño and Buot, 2010). The distribution of Mengkulang in natural forests is scattered.

If harvesting is not done with good management, the presence of this species will rapidly decline, preventing its commercialization as a valuable timber species. The flowering and fruiting of this species in nature are low, leading to low natural regeneration (PROSEA, 1994). This tree species has been reported to be used as particleboard (Sahromi et al., 2015).

In *Heritiera javanica* wood, the moisture content is 51,00 %, density is 0,52 g/cm^3, air-dried density is 0,640 g/cm^3, bending strength is 68,00–92,00 MPa, modulus of elasticity is 10600–12200 MPa, maximum compression strength is 31,80–50,30 MPa, hardness is 4230,00–4674,00 N, parallel shear strength (radial) is 9,90 MPa, parallel shear strength (tangential) is 11,70 MPa, splitting resistance (radial) is 57,00 N/cm, and splitting resistance (tangential) is 63,00 N/cm (Shan, 1988).

In this study, the changes caused by wood bleaching chemicals in mengkulang (*Heritiera javanica* (Blume) Kosterm.) wood were determined.

Materials and Methods

Wood Material

Mengkulang (*Heritiera javanica* (Blume) Kosterm.) wood was selected as the focus of this investigation. Test specimens were fashioned to dimensions of 100 mm×100 mm×15 mm. Following this, the samples underwent environmental conditioning at 20±2 °C and 65 % relative humidity (ISO 554, 1976).

Bleaching Chemicals

Oxalic acid ($C_2H_2O_4$) and hydrogen peroxide (H_2O_2) + sodium hydroxide (NaOH) were utilized as bleaching agents in this study.

Application of Bleaching

These chemicals were applied to the wooden material surfaces using a single-coat application technique.

Determination of Glossiness Characteristics

Glossiness measurements were performed utilizing the ETB-0833 model gloss meter device in accordance with the ISO 2813 (1994) standard at three distinct angles (20°, 60° and 85°) in both perpendicular and parallel orientations to the fibers.

Determination of Whiteness Index (*WI**) Characteristics

In this research, the Whiteness Meter BDY-1 instrument was employed to measure the whiteness index (WI*) values, following the ASTM E313-15e1 standard of 2015.

Determination of Shore D Hardness Value

The Shore D hardness value was determined in accordance with ASTM D 2240 (2010). The measurements were taken using a Stand: model Ld-J Loyka and a Durometer from Shenzhen Yibai Network Technology Co., Ltd., Guangdong, China, with a 5 kg load applied. A total of 10 measurements were conducted.

Color Measurements Determination of Color Characteristics

The color change of the samples was measured using the CS-10 (CHN Spec, China) device according to ASTM D 2244-3 (2007) standard, [CIE 10° standard observer; CIE D65 light source, illumination system: 8/d (8°/diffuse illumination)]. The examination was carried out utilizing the CIELAB color model. The comprehensive alterations in color were assessed utilizing the provided equations.

$$\Delta a^* = \left(a^*_{bleached\ applied}\right) - \left(a^*_{control}\right), \quad (1)$$

$$\Delta L^* = \left(L^*_{bleached\ applied}\right) - \left(L^*_{control}\right), \quad (2)$$

$$\Delta a^* = \left(a^*_{bleached\ applied}\right) - \left(a^*_{control}\right), \quad (3)$$

$$\Delta E^* = \left(\left(\Delta L^*\right)^2 + \left(\Delta b^*\right)^2 + \left(\Delta a^*\right)^2\right)^{1/2}, \quad (4)$$

$$C^* = \left(\left(a^*\right)^2 + \left(b^*\right)^2\right)^{1/2}, \quad (5)$$

$$\Delta C^* = \left(C^*_{bleached\ applied}\right) - \left(C^*_{control}\right), \quad (6)$$

$$h^o = arctan\ \left(b^*/a^*\right), \quad (7)$$

$$\Delta H^* = ((\Delta E^*)^2 - (\Delta L^*)^2 - (\Delta C^*)^2)^{1/2}. \quad (8)$$

The definitions of Δa^*, ΔC^*, Δb^*, and ΔL^* are presented in Table 1 according to Lange (1999).

The comparison criteria for the visual evaluation of the calculated ΔE^* color difference are provided in Table 2 according to DIN 5033 (1979).

Table 1

The definitions of Δa^*, ΔC^*, Δb^* and ΔL^* (Lange, 1999)

Test	Positive Description	Negative Description
Δb^*	More yellow than the reference	More blue than the reference
ΔL^*	Lighter than the reference	Darker than the reference
Δa^*	More red than the reference	More green than the reference
ΔC^*	Clearer, brighter than the reference	More dull, matte than the reference

Table 2

Comparison criteria for ΔE* evaluation
(DIN 5033, 1979)

Visual	Total Color Difference	Visual	Total Color Difference
Undetectable	<0,2	Very Distinct	3,0–6,0
Very Weak	0,2–0,5	Strong	6,0–12,0
Weak	0,5–1,5	Very Strong	> 12,0
Distinct	1,5–3,0		

Statistical Analysis

In this research, SPSS software was utilized to examine various factors, encompassing minimum and maximum values, group identification based on similar characteristics, standard deviations, percentage variations (%), multivariate coefficients of variation, and averages.

Results and Discussion

The measurement results for shore D hardness value are provided in Table 3. According to the determined result, the shore D hardness value is 61,10 HD and ranges between 51,00–60,00 HD (Table 3).

The results for total color differences are presented in Table 4.

According to these results, the ΔE^* values were determined to be 3,73 with $C_2H_2O_4$ bleaching and 13,81 with H_2O_2 + NaOH bleaching. The ΔL^* (lighter compared to reference), Δb^* (redder compared to reference), and ΔC^* (clearer, brighter compared to reference) values were calculated as positive results (Table 4).

When compared with the color change criteria (DIN 5033, 1979), it was determined that the results corresponded to “very distinct (3,0 to 6,0)” with $C_2H_2O_4$ and “very strong (> 12,0)” with H_2O_2 + NaOH.

Table 3

Results for shore D hardness value

Mean (HD)	Standard deviation	Number of Measurements	Coefficient of Variation	Minimum	Maximum
61,10	2,38	10	3,89	59,00	66,00

Table 4

Results for total color differences

Chemical type	ΔL^*	Δa^*	Δb^*	ΔC^*	ΔH^*	ΔE^*	Color criterion (DIN 5033, 1979)
$C_2H_2O_4$	1,06	2,06	2,92	3,94	–	3,73	Very distinct (3,0 – 6,0)
H_2O_2 + NaOH	10,91	–1,04	8,41	6,23	5,74	13,81	Very strong (> 12,0)

The ΔE^* value of H_2O_2 + NaOH chemical was found to be approximately 4 times larger than that of $C_2H_2O_4$ chemical. Additionally, the Δa^* values were found to be positive (redder compared to reference) with $C_2H_2O_4$ and negative (greener compared to reference) with H_2O_2 + NaOH (Table 4).

The results of the variance analysis are presented in Table 5. The gloss test measurements taken at 20° to the fibers (‖) and perpendicular (⊥) were found to be insignificant, while all other tests were found to be significant (Table 5).

The measurement results determined for the color parameters are shown in Table 6. In terms of color parameters, increases in *b**, *L**, *C**, and ho values were observed with both bleaching agents (Table 6).

The highest measured *L** value was found with the H_2O_2+NaOH bleaching agent (50,37), while the lowest was found in the unbleached control group samples (39,46). *L** values increased by 2,69 % with $C_2H_2O_4$ bleaching and by 27,65 % with H_2O_2 + NaOH bleaching (Table 6).

For *a**, the lowest result was obtained with the H_2O_2 + NaOH bleaching agent (11.82), and the highest was found with the $C_2H_2O_4$ chemical (14,92). The *a** parameter showed an increase of 16,02 % with $C_2H_2O_4$ and a decrease of 8,09 % with the H_2O_2 + NaOH chemical (Table 6).

In the *b** value, the highest result was seen with the H_2O_2 + NaOH chemical (21,84), and the lowest was obtained in the unbleached control group samples (13,44). The *b** test showed increases with both bleaching chemicals ($C_2H_2O_4$: 21,65 % and H_2O_2 + NaOH: 62,50 %) (Table 6).

For the *C** parameter, the highest result was determined with the H_2O_2+NaOH bleaching agent (24,84), and the lowest was seen in the control group samples (18,61). Increases in *C** values were also observed with both wood bleaches ($C_2H_2O_4$: 22,12 % and H_2O_2+NaOH: 33,48 %) (Table 6).

The highest measured ho value was determined with the H_2O_2 + NaOH bleaching agent (61,60), while the lowest was found in the control group samples (46,28). Increases in ho values were recorded at 0,45 % with $C_2H_2O_4$ and 33,10 % with H_2O_2 + NaOH (Table 6).

The results for the whiteness index (*WI**) values are provided in Table 7.

Table 5

Results of variance analysis

Test	Sum of Squares	df	Mean Square	F value	Sig.
*L**	723,185	2	361,592	4798,625	0,000*
*a**	49,805	2	24,902	19,878	0,000*
*b**	364,607	2	182,304	869,056	0,000*
*C**	198,740	2	99,370	281,001	0,000*
h°	1542,117	2	771,059	546,235	0,000*
⊥20° glossiness	0,000	2	0,000		**
⊥60° glossiness	4,829	2	2,414	360,149	0,000*
⊥85° glossiness	10,616	2	5,308	344,510	0,000*
‖20° glossiness	0,000	2	0,000		**
‖60° glossiness	4,803	2	2,401	337,688	0,000*
‖85° glossiness	58,963	2	29,481	836,130	0,000*
*WI** (⊥)	109,862	2	54,931	390,197	0,000*
*WI** (‖)	150,467	2	75,233	3340,954	0,000*

*: Significant

Table 6

Results for the color parameters

Test	Bleaching Chemical Type	N	Mean	Change (%)	*HG*	*SD*	Mini-mum	Maxi-mum	COV
*L**	Control	10	39,46	–	C**	0,20	39,17	39,86	0,51
	$C_2H_2O_4$	10	40,52	↑2,69	B	0,38	40,12	41,40	0,94
	H_2O_2 + NaOH	10	50,37	↑27,65	A*	0,20	50,15	50,73	0,39
*C**	Control	10	18,61	–	C**	0,68	16,82	19,19	3,66
	$C_2H_2O_4$	10	22,54	↑21,12	B	0,50	21,37	23,14	2,21
	H_2O_2 + NaOH	10	24,84	↑33,48	A*	0,59	23,89	25,84	2,38
*b**	Control	10	13,44	–	C**	0,54	12,81	14,18	4,04
	$C_2H_2O_4$	10	16,35	↑21,65	B	0,38	15,64	16,85	2,29
	H_2O_2 + NaOH	10	21,84	↑62,50	A*	0,44	21,11	22,65	2,02
*a**	Control	10	12,86	–	B	0,73	10,89	13,43	5,71
	$C_2H_2O_4$	10	14,92	↑16,02	A*	1,73	10,08	15,79	11,61
	H_2O_2 + NaOH	10	11,82	↓8,09	C**	0,47	11,19	12,51	3,95
h°	Control	10	46,28	–	B**	1,90	43,96	49,63	4,09
	$C_2H_2O_4$	10	46.49	↑0.45	B	0,56	45,82	47,61	1,20
	H_2O_2 + NaOH	10	61,60	↑33,10	A*	0,58	60,48	62,19	0,94

COV: Coefficient of Variation, SD: Standard Deviation, *: Highest Value, **: Lowest Value.

Table 7

The results for the whiteness index (*WI**) values

Test	Bleaching Chemical Type	N	Mean	Change (%)	*HG*	*SD*	Mini-mum	Maxi-mum	COV
*WI** (‖)	Control	10	2,82	–	B**	0,10	2,70	2,90	3,66
	$C_2H_2O_4$	10	2,92	↑3,55	B	0,10	2,80	3,00	3,54
	H_2O_2 + NaOH	10	7,62	↑170,21	A*	0,21	7,40	7,90	2,82
*WI** (⊥)	Control	10	6,32	–	B**	0,52	5,40	6,80	8,20
	$C_2H_2O_4$	10	6,64	↑5,06	B	0,11	6,50	6,80	1,62
	H_2O_2 + NaOH	10	10,53	↑66,61	A*	0,38	10,00	10,90	3,58

COV: Coefficient of Variation, *SD*: Standard Deviation, *: Highest Value, **: Lowest Value.

Increases in *WI** values in both directions were identified with both bleaching agents. These increases in *WI** values were determined to be 5,06 % with $C_2H_2O_4$ and 66,61 % with H_2O_2 + NaOH perpendicular to the fibers (⊥), and 3,55 % with $C_2H_2O_4$ and 170,21 % with H_2O_2 + NaOH parallel to the fibers (‖), The lowest WI* values in both directions were found in the control group samples (⊥: 6,32 and ‖: 2,82), while the highest were obtained in the H_2O_2 + NaOH treated samples (⊥: 10,53 and ‖: 7,62) (Table 7).

Table 8 presents the results for the glossines values. Decreases were observed in glossiness values at 60° and 85° in both directions (at 60° perpendicular to the fibers: 50,68 % with $C_2H_2O_4$ and 63,70 % with H_2O_2 + NaOH; parallel to the fibers: 26,09 % with $C_2H_2O_4$ and 53,26 % with H_2O_2 + NaOH; at 85° perpendicular to the fibers: 87,14 % with $C_2H_2O_4$ and 92,86 % with H_2O_2 + NaOH; parallel to the fibers: 69,14 % with $C_2H_2O_4$ and 94,86 % with H_2O_2 + NaOH). At 60° and 85°, the highest glossiness results were obtained in the unbleached wood samples, while the lowest were found in the H_2O_2 + NaOH bleached samples. No changes were observed in gloss measurements at 20° in both directions after bleaching applications (Table 8).

Table 9 shows comparisons from various studies. The results indicate that different types of wood materials exhibit different behaviors in response to the chemicals used.

Table 8

Results for the glossiness values

Test	Bleaching Chemical Type	N	Mean	Change (%)	*HG*	*SD*	Minimum	Maximum	COV
‖20°	Control	10	0,10	–	A	0,00	0,10	0,10	0,00
	$C_2H_2O_4$	10	0,10	0,00	A	0,00	0,10	0,10	0,00
	H_2O_2 + NaOH	10	0,10	0,00	A	0,00	0,10	0,10	0,00
‖60°	Control	10	1,84	–	A*	0,05	1,80	1,90	2,81
	$C_2H_2O_4$	10	1,36	↓26,09	B	0,11	1,20	1,50	7,90
	H_2O_2 + NaOH	10	0,86	↓53,26	C**	0,08	0,80	1,00	9,81
‖85°	Control	10	3,50	–	A*	0,20	3,20	3,70	5,71
	$C_2H_2O_4$	10	1,08	↓69,14	B	0,23	0,80	1,40	20,84
	H_2O_2 + NaOH	10	0,18	↓94,86	C**	0,12	0,10	0,40	68,29
⊥20°	Control	10	0,10	–	A	0,00	0,10	0,10	0,00
	$C_2H_2O_4$	10	0,10	0,00	A	0,00	0,10	0,10	0,00
	H_2O_2 + NaOH	10	0,10	0,00	A	0,00	0,10	0,10	0,00
⊥60°	Control	10	1,46	–	A*	0,08	1,40	1,60	5,78
	$C_2H_2O_4$	10	0,72	↓50,68	B	0,10	0,60	0,90	14,34
	H_2O_2 + NaOH	10	0,53	↓63,70	C**	0,05	0,50	0,60	9,11
⊥85°	Control	10	1,40	–	A*	0,18	1,20	1,70	12,60
	$C_2H_2O_4$	10	0,18	↓87,14	B	0,12	0,10	0,40	68,29
	H_2O_2 + NaOH	10	0,10	↓92,86	B**	0,00	0,10	0,10	0,00

COV: Coefficient of Variation, SD: Standard Deviation, *: Highest Value, **: Lowest Value.

Table 9

Comparisons of Various Bleaching Studies

Wood type	Bleaching Type	After Application Change					Reference
		*b**	*a**	*L**	*h*°	C*	
Mengkulang (*Heritiera javanica* (Blume) Kosterm.)	$C_2H_2O_4$ H_2O_2 + NaOH	↑ ↑	↑ ↓	↑ ↑	↑ ↑	↑ ↑	This study
Bulletwood (*Manilkara bidentata* (A.DC.) A. Chev.)	$C_2H_2O_4$ H_2O_2 + NaOH	↑ ↑	↑ ↓	↑ ↑	↓ ↑	↑ ↑	The application of…, (2023a)
Movingui (*Distemonanthus benthamianus*)	$C_2H_2O_4$ H_2O_2 + NaOH	↑ ↑	↑ ↓	↑ ↑	↑ ↑	↑ ↑	Peker et al., (2023b)
Satinwood ceylon (*Chloroxylon swietenia* DC)	$C_2H_2O_4$ H_2O_2 + NaOH	↑ ↓	↓ ↓	↓ ↑	↑ ↑	↓ ↓	Ayata and Camlıbel, (2023)
Ilomba (*Pycnanthus angolensis* Exell)	$C_2H_2O_4$ H_2O_2 + NaOH	↑ ↓	↑ ↓	↑ ↑	↑ ↑	↑ ↓	Ayata and Bal, (2023)
Olon (*Zanthoxylum heitzii*)	$C_2H_2O_4$ H_2O_2 + NaOH	↑ ↓	↑ ↓	↑ ↑	↑ ↑	↑ ↓	Peker and Ayata, (2023)
Linden (*Tilia tomentosa* – Moench.)	$C_2H_2O_4$ H_2O_2 + NaOH	↑ ↓	↑ ↓	↓ ↑	↓ ↑	↑ ↓	Camlıbel and Ayata, (2023a)
Ekop (*Tetraberlinia bifoliolata* Haum.)	$C_2H_2O_4$ H_2O_2 + NaOH	↑ ↑	↑ ↓	↓ ↑	↑ ↑	↑ ↑	Camlıbel and Ayata, (2023b)
Izombé (*Testulea gabonensis*)	$C_2H_2O_4$ H_2O_2 + NaOH	↑ ↑	↑ ↓	↓ ↑	↑ ↑	↑ ↑	The application of…, (2023c)

Conclusions

– The gloss test measurements taken at 20° to the fibers (‖) and perpendicular (⊥) were found to be insignificant, while all other tests were found to be significant.

– The Δ*E** value was determined to be 3.73 with $C_2H_2O_4$ and 13.81 with H_2O_2 + NaOH.

– With bleaching agents, increases were observed in *WI**, *L**, *b**, *C**, and ho values in both directions, while decreases were obtained in gloss values at 60° and 85° in both directions.

– It is recommended to perform aging (natural/artificial) test performances on the materials.

References

A research on the application of single and double-component wood bleaching chemicals on movingui (Distemonanthus benthamianus Baillon) wood used in the furniture industry / *H. Peker*, *E. H. Bilginer*, *Ü. Ayata*, *O. Çamlıbel* // Sivas Cumhuriyet University Journal of Science and Technology, 2023b. № 2 (2). P. 73–79.

ASTM D 2240. Standard test method for rubber property-durometer hardness, American Society for Testing and Materials, West Conshohocken, Pennsylvania, United States. 2010. URL: https://www.astm.org (accessed 10.03.2024).

ASTM D 2244-3. Standard practice for calculation or color tolerances and color, differences from instrumentally measured color coordinates, ASTM International, West Conshohocken, PA. 2007. URL: https://www.astm.org (accessed 10.03.2024).

ASTM E313-15e1. Standard practice for calculating yellowness and whiteness indices from instrumentally measured color coordinates, ASTM International, West Conshohocken, PA. 2015. URL: https://www.astm.org (accessed 10.03.2024).

Ayata U., *Camlıbel C.* A study on the application of bleaching treatment on Satinwood ceylon (Chloroxylon swietenia DC) wood used indoors and outdoors, The Journal of Graduate School of Natural and Applied Sciences of Mehmet Akif Ersoy University. 2023. № 14 (2): P. 273–281. DOI: 10.29048/makufebed.1343434

Ayata U., *Bal B. C.* Effect of Application of various bleaching chemicals on some surface properties of Ilomba (Pycnanthus angolensis Exell) wood // EU 2nd International Conference on Health, Engineering and Applied Sciences, August 4–6, 2023. Belgrade, 2023. P. 95–105.

Camlıbel O., *Ayata U.* Application of wood bleaching chemicals on ekop wood (Tetraberlinia bifoliolata Haum.) // Fareast 2nd International Conference on Applied Sciences, October 20–22, 2023. Manila, 2023b. P. 125–135.

Camlıbel O., *Ayata U.* The bleaching application on linden wood (Tilia tomentosa – Moench.) // Fareast 2nd International Conference on Applied Sciences, October 20–22, 2023. Manila, 2023a. P. 107–116.

Chemical treatment and coating of Pinus radiata to inhibit photo-yellowing // *B. S. W. Dawson*, *F. J. Cowan*, *J. M. Uprichard*, *D. Cronshaw*, *B. A Coombridge* // Surface Coatings Australia. 10, 1995. P. 16–25.

Csiha C., Papp E. Investigation on bleaching Beech wood using environment friendly agent : In Proceedings of the XXVIth International Conference Research for Furniture Industry (ed.: Szmardzewski, J.). Poznan, Poland, 2013. P. 7–15.

DIN 5033. Deutsche Normen, Farbmessung. Normenausschuß Farbe (FNF) im DIN Deutsches Institut fur Normung eV, Beuth, Berlin Marz. 1979. URL: https://www.din.de (accessed 10.03.2024).

Finishing properties of poly urethane coating on bleached and ammonia fumigated mango wood surface / *S. Panigrahi*, *S. Rout*, *G. Sahoo*, *S. Gupta*, *V. S. Kumar* // nternational Journal of Plant & Soil Science. 2021. № 33(16). P. 57–67. DOI: 10.9734/IJPSS/2021/v33i1630523

Forest Products Laboratory, Bleaching wood, Forest Service U. S. Department of Agriculture, Madison. 1967. URL: https://research.fs.usda.gov/ (accessed 10.03.2024).

Hon D. N. S., *Minemura N.* Color and discoloration // Wood and cellulosic chemistry. 2000. P. 385–442.

ISO 2813. Paints and varnishes – determination of specular gloss of non-metallic paint films at 20 degrees, 60 degrees and 85 degrees / International Organization for Standardization, Geneva, Switzerland, 1994. URL: https://www.iso.org/standard (accessed 10.03.2024).

ISO 554 (Standard atmospheres for conditioning and/or testing, International Standardization Organization, Geneva, Switzerland, 1976. URL: https://www.iso.org/standard (accessed 10.03.2024).

Lange D. R. Fundamentals of Colourimetry – Application Report № 10e. DR Lange : New York, NY, USA, 1999. URL: https://dergipark.org.tr/ (accessed 10.03.2024).

Larano A. A., *Buot Jr I. E.* Leaf architecture of selected species of Malvaceae sensu APG and its taxonomic significance // Philippine Journal of Systematic Biology. 2010. № 4 (6). P. 21–54.

Peker H., *Ayata U.* Effects of bleaching chemicals on some surface characteristics of olon (Zanthoxylum heitzii) wood // Furniture and Wooden Material Research Journal. 2023. № 6 (2). P. 210–218. DOI: 10.33725/mamad.1369843

Pinto P. C., *Evtuguin D. V.*, *Neto C. P.* Effect of structural features of wood biopolymers on hardwood pulping and bleaching performance // Industrial & Engineering Chemistry Research, 2005. № 44 (26). P. 9777–9784. DOI: 10.1021/ie050760o

PROSEA Timber Trees : Major Comercial Timbers,. I. Sorianegara and R. H. M. J Lemuneus (Editors). Bogor, Indonesia, 1994. P. 230–234.

Sahromi S., *Purwantoro R. S.*, *Siregar H. M.* Propagation of Heritiera javanica (Blume) Koesterm. as timber tree species under several shade ıntensities and growth media, Berita Biologi, 2015. № 14 (3). P. 213–222. DOI: 10.14203/beritabiologi.v14i3.1823

Shan W. S. Research Institute of Wood Industry, Identification, properties and uses of some Southeast Asian woods / Chinese Academy of Forestry, Beijing & International Tropical Timber Organization, Yokohama, 1988. 201 p.

Sjostrom E. Wood Chemistry, Fundamentals and Applications; Academic Press : New York, 1981. URL: https://openlibrary.org/ (accessed 10.03.2024).

The application of bleaching chemicals (oxalic acid and hydrogen peroxide + sodium hydroxide) on bulletwood (Manilkara bidentata (A.DC.) A. Chev.), Sivas Cumhuriyet / *H. Peker*, *E. H. Bilginer*, *U. Ayata*, *O. Camlıbel*, *L. Gurleyen* // University Journal of Engineering Faculty. 2023a. № 1 (2). P. 48–54.

The application of different wood bleaching chemicals on izombé wood (Testulea gabonensis Pellegr.) used in indoor and outdoor designs, 2nd International Culture, Art and Communication Symposium / *H. Peker*, *E. H. Bilginer*, *U. Ayata*, *L. Gurleyen*, *O. Camlıbel.* Bayburt, Turkey. 2023c. P. 289–303.

Wood, Chemistry, Ultrastructure, Reactions / *D. Fengel*, *G. Wegener*, *W. de Gruyter*. New York, 1984. URL: https://trove.nla.gov.au/ (accessed 10.03.2024).

Zeilman J. M. Techniques and materials for finishing sculpture (Doctoral dissertation, Bowling Green State University), 1960. URL: https://openlibrary.org/ (accessed 10.03.2024).

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