ISSN: 2687-6043
e-ISSN: 2687-6035
https://dergipark.org.tr/en/pub/wie

Volume 6, Issue 2
2024
pp. 25-33

Wood Industry and Engineering

International Scientific Journal

COLOR PARAMETERS COMPARISON IN VARNISHED HEARTWOOD AND SAPWOOD OF EUCALYPTUS AND RED PINE

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Citation

Peker H., Ayata Ü. Color Parameters Comparison in Varnished Heartwood and Sapwood of Eucalyptus and Red Pine. ***Wood Industry and Engineering****. 2024; 6(2): 25-33*

Keywords

Color
Synthetic-based furniture varnish
Eucalyptus
Red pine

Abstract

This study compared the color parameters [Δa*, ΔC*, ΔH*, Δb*, ΔL*, and ΔE*, a* (red color tone), L* (lightness), b* (yellow color tone), ho (hue tone), and C* (chroma)] of synthetic-based furniture varnish coatings applied to the heartwood and sapwood of eucalyptus (*Eucalyptus camaldulensis*) and red pine (*Pinus brutia* Ten.). The results showed that the variance analyses were statistically significant. In all wood species and wood parts, the varnish application resulted in decreases in the Ho and L* parameters, while increases were observed in the A* and C* parameters. In the b* parameter, an increase was observed after varnish application on red pine heartwood and sapwood, as well as eucalyptus sapwood, while a decrease was found in eucalyptus heartwood. The total color differences (ΔE*) were measured as 9.49 for the heartwood of red pine, 9.20 for its sapwood, 7.41 for the heartwood of eucalyptus, and 12.55 for its sapwood. In red pine, the ΔE* values for heartwood and sapwood were found to be very similar, while a different result was observed for eucalyptus wood. The SPSS results from the study demonstrated the significance of the changes observed after the varnish application.

Paper Type

Research Article

Article History

Received: 15/10/2024
Accepted: 24/11/2024

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COLOR PARAMETERS COMPARISON IN VARNISHED HEARTWOOD AND SAPWOOD OF EUCALYPTUS AND RED PINE

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1. Introduction

Wood has been the most accessible and renewable material throughout human history. Currently, wood consumption exceeds that of any other material. The wood product industry continues to grow rapidly. Green lumber, typically used as raw material for final products, has several characteristics that limit its use. For example, it shrinks and can crack during the drying process, it is highly hygroscopic, and it is susceptible to decay and combustion. Among the many wood treatment methods, two primary processes are commonly used in the production of wood products: one involves removing moisture (drying, through dehydration, or extraction), and the other introduces specific substances into the wood in either liquid or vapor form (Botannini, 2011).

Surface finishing is any process carried out to modify or improve the properties of objects (Nerey, 2002; 2007). The adhesion of liquid surface treatments largely depends on the properties of the substrate surface, which significantly affects their consumption and, consequently, the increase in production costs (Roffael, 1993; Carrasco, 2007). It is essential to properly adjust processing conditions to achieve the required surface quality; this means reducing raw material waste and, consequently, minimizing defects that lead to product rejection and unnecessary wear on tools, which in the long term foresees greater benefits for the wood industry (Reinoso et al., 2019).

Finishes are materials or products that are integrated, adhered, or overlaid onto the structural elements of architectural objects. They are used to enhance user comfort, emphasize the expression of spaces and forms, and protect against the harmful effects of temperature, rain, humidity, and environmental pollution. Finishes are defined for roofs, interior and exterior surfaces; ceilings, walls, and floors. They are selected based on the economic level of the architectural object, its appearance, resistance to wear, and comfort (Garza Contreras, 2019).

When exposed to external elements, unpainted or unsealed wood experiences various forms of deterioration due to atmospheric conditions. The surfaces of a board or other wooden piece may exhibit what is commonly known as raised grain, resulting in a rough, wrinkled, or fuzzy texture. This can lead to the emergence of small cracks and splits, which may sometimes develop into larger fissures that encompass the entire piece of wood. Additionally, wood is prone to warping, which can cause it to detach from the components that hold it in place. Ultimately, the fibers on the surface deteriorate and scatter, resulting in the gradual erosion of the exposed layers of wood (Deka et al., 2003; Guzmán Mejía, 2016).

Water adheres to cell walls because of the presence of hydroxyl groups (Giordano, 1971) and possesses a refractive index that differs from that of wood, which affects the quantity of light that is absorbed and reflected. Consequently, the wood's color changes as the water content in the cell walls fluctuates. This concept is valid when observing a limited area of wood that appears colorimetrically uniform (Cecchini, 2014).

Synthetic paints contain components such as petroleum derivatives and mineral substances. They are also often referred to by terms like acrylic, plastic, or water-based. In fact, manufacturers typically use the term "synthetic" mainly for paints based on organic solvents, particularly enamels and varnishes. Most of the paints available on the market today are synthetic (Trischler and Partner, 2004; Escala Martínez, 2018).

Coatings like varnishes and sealants serve an important function by forming a barrier that prevents moisture infiltration and reduces exposure to biological factors. Furthermore, choosing the appropriate wood species and performing regular maintenance help to prolong the life of wooden structures (Zacarias et al., 2024).

There are various studies in the literature that have focused on the application of different varnishes to wood surfaces. These studies have measured color properties on varnished surfaces, and the results obtained for the parameters have been discussed and explained. Examples of wood species studied include ayous (Ayata and Ayata, 2024), white oak, Korean red pine, walnut, merbau, Japanese larch, zelkova, and red oak (Kim and Kim, 2021), poplar, lati, mangga, balau red, and awoura (Ayata and Bal, 2024), cumaru and pau marfim (Mendes et al., 2016), sipo and mahogany (Ayata et al., 2024a), mahogany and Chinese white poplar (Liu et al., 2021), black locust (Ayata et al., 2024b), and Scots pine (Can and Sivrikaya, 2014).

This research focused on evaluating the color parameters and total color changes in various wood species (heartwood and sapwood) treated with a synthetic-based furniture varnish. The species studied were eucalyptus (*Eucalyptus camaldulensis*) and red pine (*Pinus brutia* Ten.). A review of the current literature revealed a lack of studies on the application of synthetic-based varnishes to these specific wood types. The outcomes of this study are expected to offer valuable information regarding the properties of the wood species, their distinct parts, and the impact of the varnish treatment.

2. Materials and Methods

2.1. Materials

2.1.1. Wood Materials

Wood samples of eucalyptus (*Eucalyptus camaldulensis*) and red pine (*Pinus brutia* Ten.) were cut to 100 mm x 100 mm x 15 mm. These samples underwent conditioning procedures at a temperature of 20±2°C and a relative humidity of 65%, following the guidelines set by ISO 554 (1976).

2.1.2. Sandpapers

In the research, sandpapers with grits of 80, 120, and 150 were obtained through purchase.

2.1.3. Synthetic-Based Furniture Varnish

In this research, a synthetic-based furniture varnish (colorless, with a solid content of 48±10% and a specific gravity of 0.90±1 g/cm^3) was obtained by purchasing it from a specialized company.

2.2. Method

2.2.1. Application of Synthetic Furniture Varnish on Wooden Material Surfaces

The varnished wood surfaces were thoroughly cleaned of dust, dirt, and oil. It was ensured that the wood surface was dry and free of moisture. Two layers of varnish were applied with a brush (coverage: 10-12 m^2/l, drying time: touch-dry in 8 h, fully dry in 24 h).

The samples were varnished following the manufacturer's guidelines and in compliance with the ASTM D 3023-98 (2017) standard.

2.2.2. Analysis of Color Parameter Properties

A CS-10 device (CHN Spec, China) was used to evaluate the color change of the samples, in accordance with the CIELAB color system and ASTM D 2244-3 (2007) standard [CIE 10° standard observer; CIE D65 light source, illumination geometry: 8/d (8°/diffuse illumination)]. Table 1, adapted from Lange (1999), provides definitions for Δa^*, ΔC^*, Δb^*, and ΔL^*.

Table 1: The definitions of Δa^*, ΔC^*, Δb^*, and ΔL^* (Lange 1999)

Test	Negative Description	Positive Description
Δb^*	Bluer than the reference	More yellow than the reference
ΔL^*	Darker than the reference	Lighter than the reference
Δa^*	Greener than the reference	Redder than the reference
ΔC^*	More dull, matte than the reference	Clearer, brighter than the reference

Table 2 illustrates alternative criteria for the visual assessment of the calculated ΔE^* color difference, following the DIN 5033 (1979) standards.

Table 2: Comparison criteria for ΔE^* evaluation (DIN 5033 1979)

Visual	Total Color Difference
Undetectable	<0.20
Very Weak	0.20 - 0.50
Weak	0.50 - 1.50
Distinct	1.50 - 3.00
Very Distinct	3.00 - 6.00
Strong	6.00 - 12.00
Very Strong	> 12.00

The following formulas were utilized to calculate the total color difference results.

$$\Delta a^* = [a^*_{\text{synthetic-based furniture varnish applied}}] - [a^*_{\text{control}}] \quad (1)$$
$$\Delta L^* = [L^*_{\text{synthetic-based furniture varnish applied}}] - [L^*_{\text{control}}] \quad (2)$$
$$\Delta b^* = [b^*_{\text{synthetic-based furniture varnish applied}}] - [b^*_{\text{control}}] \quad (3)$$
$$\Delta E^* = [(\Delta L^*)^2 + (\Delta b^*)^2 + (\Delta a^*)^2]^{1/2} \quad (4)$$
$$C^* = [(a^*)^2 + (b^*)^2]^{1/2} \quad (5)$$
$$\Delta C^* = [C^*_{\text{synthetic-based furniture varnish applied}}] - [C^*_{\text{control}}] \quad (6)$$
$$h^o = \arctan [b^*/a^*] \quad (7)$$
$$\Delta H^* = [(\Delta E^*)^2 - (\Delta L^*)^2 - (\Delta C^*)^2]^{1/2} \quad (8)$$

2.3. Statistical Analysis

Statistical analysis was conducted using a statistical software package on the measurement data gathered for the study. This involved identifying homogeneity groups, calculating standard deviations, computing mean values associated with the measurements, determining the maximum and minimum mean values, calculating percentage (%) change rates, and performing variance analyses.

3. Results and Discussion

In Table 3, the results of the variance analysis for red pine (Pinus brutia Ten.) are presented. The variance analysis conducted after the application of varnish to the heartwood and sapwood of red pine showed that the wood part (A), varnish application (B), and the interaction (AB) were found to be statistically significant (Table 3).

Table 3: Results of variance analysis (*: significant) for red pine (*Pinus brutia* Ten.)

Test	Source	Sum of Squares	Degrees of Freedom	Mean Square	F Value	Sig.
L*	**Wood Part (A)**	2022.226	1	2022.226	1620.403	0.000*
	Varnish Application (B)	321.319	1	321.319	257.472	0.000*
	Interaction (AB)	12.045	1	12.045	9.652	0.004*
	Error	44.927	36	1.248		
	Total	173038.568	40			
	Corrected Total	2400.517	39			
a*	**Wood Part (A)**	337.329	1	337.329	2276.283	0.000*
	Varnish Application (B)	124.962	1	124.962	843.241	0.000*
	Interaction (AB)	7.552	1	7.552	50.958	0.000*
	Error	5.335	36	0.148		
	Total	5508.021	40			
	Corrected Total	475.177	39			
b*	**Wood Part (A)**	15.364	1	15.364	56.539	0.000*
	Varnish Application (B)	391.563	1	391.563	1440.981	0.000*
	Interaction (AB)	16.218	1	16.218	59.684	0.000*
	Error	9.782	36	0.272		
	Total	28501.201	40			
	Corrected Total	432.927	39			
C*	**Wood Part (A)**	12.848	1	12.848	87.794	0.000*
	Varnish Application (B)	523.669	1	523.669	3578.327	0.000*
	Interaction (AB)	5.573	1	5.573	38.079	0.000*
	Error	5.268	36	0.146		
	Total	34011.848	40			
	Corrected Total	547.359	39			
***h*º**	**Wood Part (A)**	1316.412	1	1316.412	1434.962	0.000*
	Varnish Application (B)	32.490	1	32.490	35.416	0.000*
	Interaction (AB)	12.600	1	12.600	13.735	0.001*
	Error	33.026	36	0.917		
	Total	182325.274	40			
	Corrected Total	1394.528	39			

Table 4 provides the results for color parameters of red pine (*Pinus brutia* Ten.). With the application of varnish to heartwood and sapwood of red pine, decreases were observed in *b** (heartwood: 21.30% and sapwood: 32.21%), *C** (heartwood: 24.72% and sapwood: 32.75%), and *L** (heartwood: 10.99% and sapwood: 6.12%) values, while increases were detected in *h*º (heartwood: 64.64% and sapwood: 0.93%) and *a** (heartwood: 36.91% and sapwood: 38.25%) values (Table 4).

The highest *L** and *h*º values were found in the samples where varnish was not applied, whereas the lowest results were detected on the varnished test samples. In addition, the lowest *C**, *b**, and *a** values were obtained in the samples without varnish, while the highest results were found in the varnished test samples (Table 4).

Table 4: Results for color parameters for red pine (*Pinus brutia* Ten.)

Test	Wood Part	Varnish Application	Mean	Change (%)	Homogeneity Group	Standard Deviation	Mini-mum	Maxi-mum	Coefficient of Variation
L*	**Heart**	**No**	61.59	↓10.99	C	1.10	59.58	63.27	1.79
		Yes	54.82		D**	1.86	52.60	57.14	3.40
	Sap	**No**	74.71	↓6.12	A*	0.15	74.45	74.95	0.20
		Yes	70.14		B	0.53	69.45	70.83	0.75
a*	**Heart**	**No**	11.92	↑36.91	B	0.34	11.36	12.50	2.83
		Yes	16.32		A*	0.61	15.47	17.05	3.72
	Sap	**No**	6.98	↑38.25	D**	0.08	6.85	7.09	1.10
		Yes	9.65		C	0.32	9.16	10.04	3.33
b*	**Heart**	**No**	23.38	↑21.30	C	0.32	22.71	23.88	1.37
		Yes	28.36		B	0.87	26.94	29.66	3.07
	Sap	**No**	23.34	↑32.31	C**	0.28	22.97	23.91	1.22
		Yes	30.88		A*	0.38	30.24	31.31	1.24
C*	**Heart**	**No**	26.25	↑24.72	C	0.18	25.93	26.50	0.68
		Yes	32.74		A*	0.52	31.73	33.45	1.58
	Sap	**No**	24.37	↑32.75	D**	0.28	24.01	24.92	1.16
		Yes	32.35		B	0.45	31.67	32.85	1.40
***h*°**	**Heart**	**No**	62.98	↓4.64	B	0.94	61.17	64.55	1.49
		Yes	60.06		C**	1.61	58.11	62.44	2.69
	Sap	**No**	73.33	↓0.93	A*	0.22	73.01	73.70	0.30
		Yes	72.65		A	0.37	72.20	73.23	0.51
10 measurements were taken from each group, *: Highest value, **: Lowest value									

Table 5 shows the results of the variance analysis for Eucalyptus (Eucalyptus camaldulensis). The results of the variance analysis conducted on the varnish application to the heartwood and sapwood of eucalyptus revealed that the factors of wood type (A), varnish treatment (B), and their interaction (AB) were all found to be statistically significant (Table 5).

Table 5: Results of variance analysis (*: significant) for eucalyptus (*Eucalyptus camaldulensis*)

Test	Source	Sum of Squares	Degrees of Freedom	Mean Square	F Value	Sig.
L*	**Wood Part (A)**	3717.762	1	3717.762	17253.911	0.000*
	Varnish Application (B)	562.575	1	562.575	2610.877	0.000*
	Interaction (AB)	20.924	1	20.924	97.105	0.000*
	Error	7.757	36	0.215		
	Total	99792.208	40			
	Corrected Total	4309.018	39			
a*	**Wood Part (A)**	345.098	1	345.098	4630.472	0.000*
	Varnish Application (B)	224.250	1	224.250	3008.951	0.000*
	Interaction (AB)	30.994	1	30.994	415.868	0.000*
	Error	2.683	36	0.075		
	Total	9223.413	40			
	Corrected Total	603.024	39			
b*	**Wood Part (A)**	100.743	1	100.743	1684.083	0.000*
	Varnish Application (B)	20.420	1	20.420	341.361	0.000*
	Interaction (AB)	202.680	1	202.680	3388.134	0.000*
	Error	2.154	36	0.060		
	Total	11625.679	40			
	Corrected Total	325.997	39			
C*	**Wood Part (A)**	23.409	1	23.409	304.750	0.000*
	Varnish Application (B)	190.969	1	190.969	2486.126	0.000*
	Interaction (AB)	169.168	1	169.168	2202.306	0.000*
	Error	2.765	36	0.077		
	Total	20853.792	40			
	Corrected Total	386.311	39			
***h*°**	**Wood Part (A)**	2947.231	1	2947.231	8454.834	0.000*
	Varnish Application (B)	691.143	1	691.143	1982.708	0.000*
	Interaction (AB)	43.410	1	43.410	124.531	0.000*
	Error	12.549	36	0.349		
	Total	101562.813	40			
	Corrected Total	3694.332	39			

Table 6 includes the results for color parameters of eucalyptus (*Eucalyptus camaldulensis*). When looking at the varnish application on heartwood and sapwood of eucalyptus, decreases were observed in h^o (heartwood: 22.57% and sapwood: 10.19%) and L^* (heartwood: 14.38% and sapwood: 14.20%) values, while increases were obtained in C^* (heartwood: 1.07% and sapwood: 48.21%) and a^* (heartwood: 18.47% and sapwood: 76.35%) values (Table 6).

As for b^* values, a decrease of 18.38% was found in heartwood, while an increase of 38.43% was detected in sapwood. The lowest C^* and a^* values were observed in the samples without varnish, while the highest results were obtained in the varnished test samples. Additionally, the highest L^* and h^o values were found in the samples without varnish, whereas the lowest results were seen on the varnished test samples (Table 6).

Table 6: Results for color parameters for eucalyptus (*Eucalyptus camaldulensis*)

Test	Wood Part	Varnish Application	Mean	Change (%)	Homogeneity Group	Standard Deviation	Mini-mum	Maxi-mum	Coefficient of Variation
L*	**Heart**	**No**	42.24	↓14.32	C	0.27	41.84	42.72	0.64
		Yes	36.19		D**	0.50	35.58	37.01	1.38
	Sap	**No**	62.97	↓14.20	A*	0.36	62.59	63.75	0.58
		Yes	54.03		B	0.64	52.25	54.43	1.18
a*	**Heart**	**No**	16.13	↑18.47	B	0.33	15.70	16.60	2.03
		Yes	19.11		A*	0.36	18.54	19.54	1.87
	Sap	**No**	8.50	↑76.35	D**	0.18	8.28	8.82	2.18
		Yes	14.99		C	0.17	14.69	15.28	1.14
b*	**Heart**	**No**	16.76	↓18.38	B	0.21	16.51	17.10	1.23
		Yes	13.68		D**	0.35	13.31	14.25	2.54
	Sap	**No**	15.43	↑38.43	C	0.19	15.02	15.63	1.26
		Yes	21.36		A*	0.20	21.07	21.60	0.91
C*	**Heart**	**No**	23.26	↑1.07	C	0.27	22.79	23.70	1.17
		Yes	23.51		B	0.37	22.91	24.05	1.57
	Sap	**No**	17.61	↑48.21	D**	0.24	17.16	17.89	1.34
		Yes	26.10		A*	0.20	25.73	26.39	0.78
***h*º**	**Heart**	**No**	46.08	↓22.57	C	0.65	44.98	46.97	1.42
		Yes	35.68		D**	0.83	34.36	36.81	2.33
	Sap	**No**	61.16	↓10.19	A*	0.39	60.47	61.90	0.64
		Yes	54.93		B	0.35	54.05	55.22	0.64
10 measurements were taken from each group, *: Highest value, **: Lowest value									

Finally, Table 7 presents the calculated results for total color differences (ΔH^*, Δa^*, ΔC^*, Δb^*, ΔL^*, and ΔE^*). The total color differences (ΔE^*) were determined as follows: 9.49 for red pine heartwood, 9.20 for red pine sapwood, 7.41 for eucalyptus heartwood, and 12.55 for eucalyptus sapwood. Upon examining the results for total color differences, it was found that the varnished samples of eucalyptus sapwood exhibited a very strong criterion (> 12.00), while the varnished samples of eucalyptus heartwood, as well as red pine heartwood and sapwood, showed a strong criterion (6.00 to 12.00) (Table 7).

For all varnished wood species and wood parts, the ΔL^* values were negative (darker than the reference), while the Δa^* values were positive (redder than the reference). In addition, the ΔC^* values were found to be positive (clearer, brighter than the reference). Regarding the Δb^* values, it was observed that for eucalyptus heartwood, the value was negative (bluer than the reference), while for the other samples, it was positive (more yellow than the reference). ΔH^* values were calculated as 4.27 for eucalyptus heartwood, 2.33 for eucalyptus sapwood, 1.45 for red pine heartwood, and 0.31 for red pine sapwood (Table 7).

Table 7: Calculated results for total color differences

Wood Type	Wood Part	Δ*L**	Δ*a**	Δ*b**	Δ*C**	Δ*H**	Δ*E**	Color Change Criteria (DIN 5033, 1979)
Red pine	**Heart**	-6.77	4.40	4.98	6.49	1.45	9.49	Strong (6.00 - 12.00)
	Sap	-4.57	2.67	7.53	7.98	0.31	9.20	
Eucalyptus	**Heart**	-6.05	2.97	-3.07	0.26	4.27	7.41	
	Sap	-8.95	6.50	5.93	8.48	2.33	12.55	Very Strong (> 12.00)

The study successfully met its aim. The type of varnish applied resulted in the formation of varying color parameters. The varnish component used in the study may have interacted with wood material, leading to the formation of different color characteristics.

Studies in the literature have reported that varnish applications lead to changes in the color properties of wood surfaces. These findings have been observed in various wood species, including mahogany and Chinese white poplar (Liu et al., 2021), ayous (Ayata and Ayata, 2024), cumaru and pau marfim (Mendes et al., 2016), Scots pine (Can and Sivrikaya, 2014), sipo and mahogany (Ayata et al., 2024a), poplar, lati, balau red, mangga, and awoura (Ayata and Bal, 2024), black locust (Ayata et al., 2024b), as well as Korean red pine, Japanese larch, merbau, zelkova, walnut, white oak, and red oak (Kim and Kim, 2021).

4. Conclusion

For the b^* parameter, varnish application led to an increase in red pine heartwood and sapwood, as well as eucalyptus sapwood, whereas a decrease was observed in eucalyptus heartwood. For all wood species and wood parts, the varnish application led to a reduction in Ho and L* parameters, whereas A* and C* parameters showed an increase. The ΔE^* values were measured as 9.49 for the heartwood of red pine, 9.20 for its sapwood, 7.41 for the heartwood of eucalyptus, and 12.55 for its sapwood. The SPSS results obtained in the study highlighted the significance of the changes following the varnish application.

According to the results, it is expected that the heartwood or sapwood will be used according to the consumer's taste in terms of desired color characteristics in the industry.

Disclosure Statement

No potential conflict of interest was reported by the authors.

References

ASTM D 2244-3, (2007). Standard Practice for Calculation or Color Tolerances and Color, Differences from Instrumentally Measured Color Coordinates, ASTM International, West Conshohocken, PA.

ASTM D 3023-98, (2017). Standard Practice for Determining The Resistance of Factory-Applied Coatings on Wood Products to Stains and Reagents, West Conshohocken, Pennsylvania, United States.

Ayata, Ü., and Ayata, A., (2024). Ayous Odununda Renk Özellikleri Üzerine Resim Verniğinin, Isıl Işlemin ve Sirke İle Karbonat Kullanarak Hazırlanmış Olan Çözeltinin Etkileri, Technological Applied Sciences, 19(3): 23-33. DOI: 10.12739/NWSA.2024.19.3.2A0198.

Ayata, Ü., and Bal, B.C., (2024). Lati, Mangga, Balau Red, Karakavak ve Awoura Odun Türlerinde Sentetik Vernik Uygulamasının Yapılması, Uzakdoğu 3. Uluslararası Uygulamalı Bilimler Kongresi, 2-9 Ekim 2024, Pekin, Çin, 128-137.

Ayata, Ü., Bilginer, E.H., Çamlıbel, O., and Ayata, A., (2024a). Sipo (*Entandrophragma utile*) ve Maun (*Swietenia mahagoni* L.) odunlarında Yat Verniği Uygulamasının Renk Değişikliği Üzerine Etkisinin Araştırılması, Technological Applied Sciences, 19(2) 16-22. DOI: 10.12739/NWSA.2024.19.2.2A0197.

Ayata, Ü., Bilginer, E.H., Çamlıbel, O., and Kaplan, Ş., (2024b). Yalancı Akasya (*Robinia pseudoacacia* L.) Ahşabı Yüzeylerine Uygulanmış Solvent Bazlı Yat Verniği Katmanlarında Bazı Yüzey Özellikleri Üzerine Kat Sayısının Etkileri, Artvin Çoruh Üniversitesi Mühendislik ve Fen Bilimleri Dergisi, 2(1) 41-49.

Botannini, L.F., (2011). Wood: Types, Properties, and Uses; Nova Science Publishers Inc.: Hauppauge, NY, USA, pp. 1-244. ISBN 9781616688370.

Can, A., & Sivrikaya, H. (2014). Effects of Nano-Zinc Oxide-Based Paint on the Weathering Performance of Coated Wood. Proceedings of the 3rd International Conference on Processing Technologies for the Forest and Bio-based Products Industries (PTF BPI 2014) Kuchl/Salzburg, Austria, September 24-26, 2014.

Carrasco, T.E.N., (2007). Efecto del Lijado Sobre Madera de *Pinus radiata* D. Don en Los Niveles de Consumo de Barnices.

Cecchini, C., (2014). Plastiche Senza Petrolio: Dalle Lacche Cinesi Ai Bio-Polimeri del Futuro. AA.VV. Lectures. vol. 2 (pp. 23-45). Rome: Rdesignpress.

Deka, M., Humar, M., Rep, G., Kričej, B., Šentjurc, M., and Petrič, M. (2008). Effects of UV Light Irradiation on Colour Stability of Thermally Modified, Copper Ethanolamine-Treated, and Non-Modified Wood: EPR and DRIFT Spectroscopic Studies. Wood Science and Technology, 42(5) 5-20. DOI: 10.1007/s00226-007-0147-4.

DIN 5033 (1979). Deutsche Normen, Farbmessung. Normenausschuß Farbe (FNF) im DIN Deutsches Institut für Normung eV, Beuth, Berlin, März.

Escala Martínez, S.F., (2018). Propuesta de Barniz A Base de Baba de Nopal aplicado En Tableros Y Madera Natural de Pino, Facultad de Ingeniería, Escuela de Construcción Civil.

Garza Contreras, A., (2019). Los Acabados en La Edificación Básica.

Giordano, G., (1971). Tecnologia del Legno, Volume I, La Materia Prima. Torino: Unione Tipografico - Editrice Torinese.

Guzmán Mejía, I.Q.E. (2016). Polyurethane Coating from Abietic Acid, Department of Wood Engineering and Technology, Universidad Michoacana de San Nicolás de Hidalgo, Master Thesis.

ISO 554, (1976). Standard Atmospheres for Conditioning and/or Testing, International Standardization Organization, Geneva, Switzerland.

Kim, J.Y., & Kim, B.R. (2021). Hygroscopicity and Ultraviolet (UV) Deterioration Characteristics of Finished Woods. Journal of the Korean Wood Science and Technology, 49(5) 471-481. DOI: 10.5658/WOOD.2021.49.5.471.

Lange, D.R., (1999). Fundamentals of Colourimetry - Application Report No. 10e. DR Lange: New York, NY, USA.

Liu, Q., Gao, D., and Xu, W. (2021). Influence of The Bottom Color Modification and Material Color Modification Process on The Performance of Modified Poplar. Coatings, 11(6) 660. DOI: 10.3390/coatings11060660.

Mendes, T.J., Gonçalez, J.C., Teles, R. F., & Lima, C. M. (2016). Effect of Artificial Weathering on Wood Laminates Color Treated with Two Finishing Products. Cerne, 22(1) 101-110. DOI: 10.1590/01047760201622011911.

Nerey, L., (2002). Acabados Superficiales Electroquímicos en La Industria, Parque Tecnológico de Mérida, Salpica. Mérida.

Nerey, L., (2007). Consideraciones Técnicas de Los Acabados Superficiales en el Diseño de Nuevos Productos. XI Congreso Internacional de Ingeniería de Proyectos, Lugo, España, 26-28 de Septiembre de 2007, 1867-1878.

Reinoso, R.H.V., Concepción, R.R.F., Sánchez, M.A.L., Simón, N.C., and Lazo, D.A.Á., (2019). Analysis of Surface Roughness of Different Woods in The Provinces of Pinar del Río and Artemisa, Cuba, Revista Cubana de Ciencias Forestales, 7(1) 1-16.

Roffael, E., and Schneider, T. (1993). Investigation on Partial Subtitution of Strands in Oriented Strand Boards (OSB) by Different Lignocellulosic Raw Materials. Institute for Wood Biology and Wood Technology. Georg August University of Göttingen Busgenweg.

Trischler, & Partner, (2004). Qué pintamos nosotros? La pintura de Pared, Revista Options, Septiembre-Noviembre 2004.

Zacarias, D.C., Hermosillo, M.G., López, L.W., Segoviano, M.H., Rangel, J.Y., Saldaña, M.S., Correa Guerra, D.M., Guzmán Álvarez, G., and Núñez, R.Z., (2024). Aplicación Y Caracterización de La Formulación Base Quitosano Y Partículas de TiO2 en Madera. Verano de la Ciencia, 28.