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INVESTIGATION OF COLOR CHARACTERISTICS OF SOME TYPES OF WOOD TREATED WITH COLORED VARNISH WOOD PRESERVATIVE

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Abstract

In this study, color parameters and total color differences were compared among wood species treated with colored varnish wood preservative (blue and rosewood colors, 2 coats) including Maritime pine (*Pinus pinaster*), Russian olive (*Elaeagnus angustifolia* L.), Persian silk (*Albizia julibrissin*), American walnut (*Juglans nigra*), mulberry (*Morus alba*), black alder (*Alnus glutinosa* L. Gaertn.), mahogany (*Swietenia mahagoni* (L.) Jacq.), and ayous (*Triplochiton scleroxylon* K. Schum). According to the obtained results, variance analyses were found to be significant. Decreases were observed in the L*, a*, b*, and C* values with the application of blue varnishes across all wood species, while increases were obtained in the ho values. Similarly, decreases were recorded in the L* and ho values with the application of rose varnishes on all wood species.

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INVESTIGATION OF COLOR CHARACTERISTICS OF SOME TYPES OF WOOD TREATED WITH COLORED VARNISH WOOD PRESERVATIVE

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1. Introduction

Wood is primarily made up of three organic polymeric components: cellulose, hemicellulose, and lignin, which mainly define its chemical and physical characteristics. In addition, wood contains small amounts of non-structural substances, known collectively as extractives. These include compounds like fats, sugars, resins, starches, oils, alkaloids, gums, and tannins. The amount of extractives can vary widely, ranging from less than 1% to up to 10% of the oven-dry weight of the wood (Tsoumis, 1992).

Applying varnish to wood surfaces used in furniture and decoration does not guarantee that they are adequately protected. To effectively establish a protective layer with varnish, it is important to take into account the possible effects the wood might encounter in its intended application. Choosing a varnish type that offers maximum durability against these potential challenges is essential, and the application must follow the appropriate techniques. Moreover, implementing various precautions before varnishing can extend the service life of the materials (Sönmez, 2000).

Before applying any coating onto the wood surface, a product that guarantees durability, beauty, and applicability of the coating must be found. Additionally, it should be ensured that the product provides a fast drying time, good elasticity, film adhesion, and thus excellent fiber penetration (Espinoza Calderón, 1993; Rivera, 2016).

When unpainted or unvarnished wood is exposed to external factors, it undergoes various deteriorations due to atmospheric effects. The exposed surfaces of a board or other piece of wood often exhibit a condition known as 'raised grain,' which causes the surface to become rough and wrinkled or fuzzy. Small cracks and splits appear, sometimes turning into large cracks that encompass the entire wood. The board tends to warp and even escape from the pieces holding it in place. Finally, the fibers on the surface disintegrate and disperse. In this way, the exposed layers of the wood gradually wear away (Deka et al., 2003; Guzmán Mejía, 2016).

At different times, a broad spectrum of materials has been used for “varnishing”. A conventional classification could be pure drying oils, combinations of drying oils and resins, resins dissolved in turpentine spirits, and gums, which are substances soluble in water but insoluble in alcohol (Kurz, 1962).

In order to extend the aesthetic and economic lifespan of wood surfaces, paints, and varnishes are the most frequently used materials for liquid surface treatments that form a protective coating (Kurtoğlu, 2000).

Varnishes of varying compositions, when applied over different wood stains, can alter the color and shade of the stained wood surfaces. This effect may result in irreversible changes after application, leading to conflicts in furniture manufacturing (Çakıcıer, 1994). Wood is commonly coated with various decorative and protective treatments, such as penetrating finishes, semi-transparent stains, opaque paints, or clear varnishes that form a protective film, to ensure its long-term durability (George et al., 2005).

This study involved a comparison of color parameters and total color differences across various wood species treated with a colored varnish wood preservative (blue and rosewood colors, 2 coats). The wood species included in the analysis were Russian olive, maritime pine, Persian silk, mahogany, black alder, American walnut, mulberry, and ayous. An online literature review revealed that studies involving colored varnishes on these specific wood species are lacking. The findings from this study are expected to offer valuable information about both the wood species and the colored varnishes applied.

2. Materials and Methods

2.1. Materials

2.1.1. Wood Materials

Maritime pine (*Pinus pinaster*), Russian olive (*Elaeagnus angustifolia* L.), Persian silk (*Albizia julibrissin*), American walnut (*Juglans nigra*), mulberry (*Morus alba*), black alder (*Alnus glutinosa* L. Gaertn.) mahogany (*Swietenia mahagoni* (L.) Jacq.), and ayous (*Triplochiton scleroxylon* K. Schum) wood samples

were prepared in dimensions of 100 mm x 100 mm x 15 mm. The samples were subjected to conditioning treatments (20±2°C with 65% relative humidity) according to ISO 554 (1976). The wood test samples were obtained through purchase.

2.1.2. Sandpapers

In this study, 80, 120, and 150 grit sandpapers were acquired through purchase.

2.1.3. Colored Varnish Wood Preservative Chemical

The type of varnish used in the study belongs to a specialized company and is available in two different colors: blue and rosewood. It is alkyd resin-based, transparent, and resistant to UV rays (touch dry: 2-3 h, dust-free: 3-4 h, hardening: 24 h, flash point: 38oC). These types of varnishes were obtained through purchase.

2.2. Method

2.2.1. Application of Colored Varnish Wood Preservative Chemicals on Wood Material Surfaces

Before applying the varnish, the wood surfaces were sanded using 80, 120, and 150 grit sandpapers. The sanded wood surfaces were cleaned with the help of a compressor. The varnish was applied in one coat at 12-15 m^2/L using a brush, and it was applied in 1 and 2 coats. A drying period of 24 hours was allowed between coats. The varnishing of the samples was carried out according to the manufacturer's recommendations and the ASTM D3023-98 (2017) standard.

2.2.2. Determination of Color Parameters Properties

The color changes in the wood samples were assessed using a CS-10 device (CHN Spec, China), following 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)]. Definitions for ΔC*, Δa*, Δb*, and ΔL* are detailed in Table 1, adapted from Lange (1999).

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

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

Table 2 presents alternative criteria for comparing the visual assessment of the calculated ΔE* color difference, by DIN 5033 (DIN 1979) standards.

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

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

The results of total color differences were determined using the following formulas.

$\Delta a^* = [a^*_{\text{varnish applied}}] - [a^*_{\text{control}}]$ (1)

$\Delta L^* = [L^*_{\text{varnish applied}}] - [L^*_{\text{control}}]$ (2)

$\Delta b^* = [b^*_{\text{varnish applied}}] - [b^*_{\text{control}}]$ (3)

$\Delta E^* = [(\Delta L^*)^2 + (\Delta b^*)^2 + (\Delta a^*)^2]^{1/2}$ (4)

$C^* = [(a^*)^2 + (b^*)^2]^{1/2}$ (5)

$\Delta C^* = [C^*_{\text{varnish applied}}] - [C^*_{\text{control}}]$ (6)

$h^o = \arctan [b^*/a^*]$ (7)

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

2.3. Statistical Analysis

Statistical analysis was performed using a statistical software package on the measurement data collected for the study. This included calculating identifying homogeneity groups, standard deviations, computing mean-associated measurement values, determining maximum and minimum mean values, and determining percentage (%) change rates, and conducting variance analyses.

3. Results and Discussion

The results of the analysis of variance are presented in Table 3. Upon examining the variance analyses, wood type (A), varnish color (B), and the interaction (AB) were found to be significant across all tests (Table 3).

Table 3: Results of variance analysis

Source	Test	Sum of Squares	Degrees of Freedom	Mean Square	F Value	Sig. (α≤0.05)
Wood Type (A)	Lightness (L^*)	25506.013	7	3643.716	6168.479	0.000*
	Red (a^*) color tone	892.360	7	127.480	561.794	0.000*
	Yellow (b^*) color tone	4218.859	7	602.694	1519.868	0.000*
	Chroma (C^*)	4926.411	7	703.773	1731.312	0.000*
	Hue (h^o) tone	23645.310	7	3377.901	1083.026	0.000*
Varnish Color Type (B)	Lightness (L^*)	17437.839	2	8718.920	14760.336	0.000*
	Red (a^*) color tone	9470.109	2	4735.055	20866.992	0.000*
	Yellow (b^*) color tone	12261.109	2	6130.554	15459.975	0.000*
	Chroma (C^*)	17855.548	2	8927.774	21962.716	0.000*
	Hue (h^o) tone	63252.086	2	31626.043	10139.970	0.000*
Interaction (AB)	Lightness (L^*)	2095.654	14	149.690	253.411	0.000*
	Red (a^*) color tone	1856.398	14	132.600	584.356	0.000*
	Yellow (b^*) color tone	1675.036	14	119.645	301.721	0.000*
	Chroma (C^*)	2480.531	14	177.181	435.873	0.000*
	Hue (h^o) tone	23633.022	14	1688.073	541.231	0.000*

*: Significant

The results for total color differences are shown in Table 4. The ΔH* values were calculable for all wood species as they emerged positively from the root degree. Δa* values were found to be negative for both varnish colors applied to mahogany wood. For all other wood species, this parameter was obtained as negative (greener than the reference) with the blue-colored varnish, while it was determined as positive (redder than the reference) with the rose-colored varnish. In the Δb* values, the rose-colored varnish applied to black alder wood was found to be positive (more yellow than the reference), while all other wood species and their varnished states were obtained as negative (bluer than the reference). For all wood species and varnish types, the ΔL* values were obtained as negative (darker than the reference). The color change criteria were found to be “very strong (> 12.00)” for the varnishes applied to black alder, maritime pine, mahogany, ayous, mulberry, Persian silk, and American walnut wood species. In Russian olive wood, the criterion was determined as “very strong' (> 12.00)” with blue-colored varnish, while it was classified as “strong (6.00 - 12.00)” with rose-colored varnish. The ΔE* values were calculated as 17.51 for blue-colored varnish and 13.79 for rose-colored varnish on mahogany wood, 31.20 for blue-colored varnish, and

19.90 for rose-colored varnish on ayous wood, 27.58 for blue-colored varnish and 12.98 for rose-colored varnish on mulberry wood, 37.53 for blue-colored varnish and 14.73 for rose-colored varnish on Persian silkwood, 24.11 for blue-colored varnish and 12.57 for rose-colored varnish on American walnut wood, 21.02 for blue-colored varnish and 10.40 for rose-colored varnish on Russian olive wood, 31.42 for blue-colored varnish and 18.33 for rose-colored varnish on black alder wood, and 36.14 for blue-colored varnish and 15.04 for rose-colored varnish on maritime pine wood (Table 4).

Table 4: Results related to total color differences

Wood Type	Type of Varnish	ΔL^*	Δa^*	Δb^*	ΔC^*	ΔH^*	ΔE^*	Color Criterion (DIN 5033, 1979)
Mahogany	Blue	-7.88	-11.06	-11.05	-15.30	3.22	17.51	Very Strong (> 12.00)
	Rose	-6.86	-7.19	-9.57	-11.89	1.33	13.79	
Ayous	Blue	-25.62	-6.77	-16.47	-17.46	3.53	31.20	
	Rose	-17.18	9.91	-1.56	2.84	9.62	19.90	
Mulberry	Blue	-18.72	-8.47	-18.40	-20.21	1.25	27.58	
	Rose	-8.64	8.50	-4.64	0.55	9.67	12.98	
Persian silk	Blue	-27.12	-11.18	-23.42	-23.41	11.18	37.53	
	Rose	-10.81	9.90	-1.47	3.12	9.51	14.73	
American walnut	Blue	-18.98	-6.54	-13.35	-14.60	2.76	24.11	
	Rose	-11.05	5.33	-2.74	0.24	5.99	12.57	
Russian olive	Blue	-14.57	-7.01	-13.42	-15.06	1.61	21.02	
	Rose	-8.55	3.77	-4.56	-1.75	5.65	10.40	Strong (6.0 - 12.0)
Black alder	Blue	-26.75	-8.14	-14.35	-16.20	3.11	31.42	Very Strong (> 12.00)
	Rose	-13.74	11.82	2.75	8.69	8.46	18.33	
Maritime pine	Blue	-27.33	-10.84	-21.02	-21.63	9.57	36.14	
	Rose	-10.43	10.64	-2.09	3.11	10.39	15.04	

The results for ho (hue tone) values are given in Table 5. After applying varnishes to all wood species, increases were observed in hue parameters associated with blue color, while decreases were found in ho parameters associated with rose color (mahogany: blue 50.31%, rose 12.54%, mahogany: blue 16.40%, rose 25.82%, mulberry: blue 6.22%, rose 26.92%, Persian silk: blue 83.57%, rose 25.65%, American walnut: blue 22.74%, rose 24.98%, Russian olive: blue 8.59%, rose 18.59%, black alder: blue 17.63%, rose 25.50%, and maritime pine: blue 69.99%, rose 28.88%). Samples of untreated wood species were determined to be sorted from low to high ho value as follows: mahogany (49.67) < black alder (66.36) < Russian olive (65.78) < mulberry (67.34) < American walnut (69.29) < Maritime pine (72.95) < Persian silk (73.03) < ayous (74.45) (Table 5).

Table 5: Results for h^o parameter

Wood Type	Type of Varnish	Mean	Change (%)	Homogeneity Group	Standard Deviation	Mini-mum	Maxi-mum	Coefficient of Variation
Mahogany	Control	49.67	-	N	0.74	48.74	50.97	1.48
	Blue	74.66	↑50.31	F	2.42	70.30	76.61	3.24
	Rose	43.44	↓12.54	O**	2.46	40.75	47.81	5.66
Ayous	Control	74.45	-	FG	0.35	73.80	74.83	0.47
	Blue	86.66	↑16.40	C	1.07	84.47	87.80	1.24
	Rose	55.23	↓25.82	K	0.21	54.80	55.53	0.38
Mulberry	Control	67.34	-	J	0.70	66.26	68.06	1.04
	Blue	71.53	↑6.22	H	1.04	70.33	73.30	1.46
	Rose	49.21	↓26.92	N	2.34	46.93	53.95	4.76
Persian silk	Control	73.03	-	FGH	0.35	72.58	73.71	0.48
	Blue	134.06	↑83.57	A*	3.55	130.04	139.97	2.65
	Rose	54.30	↓25.65	KL	1.04	52.57	55.78	1.92
American walnut	Control	69.29	-	I	0.57	68.31	70.14	0.83
	Blue	85.05	↑22.74	D	1.57	83.60	88.85	1.84
	Rose	51.98	↓24.98	M	1.25	50.05	54.10	2.40
Russian olive	Control	65.78	-	J	0.52	64.48	66.41	0.79
	Blue	71.43	↑8.59	H	1.40	69.96	73.74	1.96
	Rose	53.55	↓18.59	L	4.77	48.44	64.67	8.91
Black alder	Control	66.36	-	J	0.45	65.43	66.95	0.68
	Blue	78.06	↑17.63	E	1.74	74.52	80.09	2.23
	Rose	49.44	↓25.50	N	0.92	48.50	51.25	1.86
Maritime pine	Control	72.95	-	GH	0.96	71.98	75.15	1.31
	Blue	124.01	↑69.99	B	1.97	119.29	126.50	1.59
	Rose	51.88	↓28.88	M	1.42	50.20	53.89	2.74
Number of Measurements: 10, *: Highest result, **: Lowest result								

Table 6: Results for L* parameter

Wood Type	Type of Varnish	Mean	Change (%)	Homogeneity Group	Standard Deviation	Mini-mum	Maxi-mum	Coefficient of Variation
Mahogany	Control	34.78	-	P	0.26	34.18	35.17	0.73
	Blue	26.90	↓22.66	T**	0.20	26.70	27.25	0.73
	Rose	27.93	↓19.70	S	0.22	27.65	28.15	0.80
Ayous	Control	67.52	-	C	0.29	67.19	68.03	0.42
	Blue	41.90	↓37.94	N	0.44	41.01	42.24	1.06
	Rose	50.34	↓25.44	I	0.38	49.43	50.88	0.76
Mulberry	Control	53.15	-	G	1.11	51.59	54.73	2.10
	Blue	34.43	↓35.22	P	0.36	33.85	34.88	1.05
	Rose	44.51	↓16.26	M	0.64	43.49	45.61	1.43
Persian silk	Control	72.65	-	B	0.39	71.77	73.12	0.53
	Blue	45.53	↓37.33	L	0.65	44.38	46.50	1.43
	Rose	61.84	↓14.88	F	0.89	60.66	63.52	1.44
American walnut	Control	49.65	-	J	1.17	48.04	51.56	2.35
	Blue	30.67	↓38.23	R	0.31	30.19	31.15	1.00
	Rose	38.60	↓22.26	O	0.96	37.11	39.49	2.48
Russian olive	Control	47.45	-	K	1.07	45.84	48.68	2.26
	Blue	32.87	↓30.73	Q	0.42	31.89	33.36	1.28
	Rose	38.89	↓18.04	O	1.85	36.24	41.21	4.74
Black alder	Control	65.15	-	D	0.39	64.59	65.69	0.60
	Blue	38.40	↓41.06	O	0.39	37.81	38.96	1.01
	Rose	51.41	↓21.09	H	1.18	49.98	53.36	2.29
Maritime pine	Control	74.17	-	A*	0.78	73.43	75.92	1.05
	Blue	46.84	↓36.85	K	0.61	45.39	47.56	1.31
	Rose	63.75	↓14.05	E	0.82	62.61	64.85	1.28
Number of Measurements: 10, *: Highest result, **: Lowest result								

The results for a* (red color tone) value are shown in Table 7. For the a* value determined by the color device, the highest result was found in the black alder test samples treated with rose varnish (21.70), while the lowest a* value was detected in the samples of Persian silk wood treated with blue varnish (-3.08). The measured a* parameter showed decreases with the application of two different colored varnishes on mahogany wood (blue varnish: 93.33% and rose varnish: 60.68%). In all other wood species, decreases were observed with the application of blue varnish (Maritime pine 139.33% > Persian silk 138.07% > American walnut 93.83% > ayous 92.12% > black alder 82.31% > mulberry 72.39% > Russian olive 70.95%), while increases were seen with the application of rose varnish (Maritime pine 136.63% > ayous 134.65% > Persian silk 122.37% > black alder 119.41% > American walnut 76.61% > mulberry 72.65% > Russian olive 38.16%) (Table 7).

Table 7: Results for a* parameter

Wood Type	Type of Varnish	Mean	Change (%)	Homogeneity Group	Standard Deviation	Mini-mum	Maxi-mum	Coefficient of Variation
Mahogany	Control	11.85	-	G	0.29	11.39	12.39	2.48
	Blue	0.79	↓93.33	O	0.15	0.60	1.00	18.48
	Rose	4.66	↓60.68	L	0.80	3.80	5.77	17.26
Ayous	Control	7.36	-	J	0.22	7.08	7.73	2.95
	Blue	0.58	↓92.12	O	0.21	0.35	1.00	35.72
	Rose	17.27	↑134.65	D	0.21	16.90	17.55	1.20
Mulberry	Control	11.70	-	G	0.29	11.30	12.25	2.46
	Blue	3.23	↓72.39	M	0.33	2.68	3.56	10.24
	Rose	20.20	↑72.65	B	0.92	18.36	21.10	4.57
Persian silk	Control	8.09	-	I	0.23	7.64	8.42	2.88
	Blue	-3.08	↓138.07	P**	0.30	-3.91	-2.85	-9.76
	Rose	17.99	↑122.37	C	0.55	17.10	18.81	3.08
American walnut	Control	6.97	-	K	0.20	6.71	7.38	2.94
	Blue	0.43	↓93.83	O	0.13	0.10	0.54	30.12
	Rose	12.31	↑76.61	F	0.87	11.19	13.39	7.08
Russian olive	Control	9.88	-	H	0.20	9.58	10.27	1.98
	Blue	2.87	↓70.95	M	0.30	2.27	3.19	10.48
	Rose	13.65	↑38.16	E	0.65	12.82	14.71	4.75
Black alder	Control	9.89	-	H	0.33	9.44	10.41	3.34
	Blue	1.75	↓82.31	N	0.33	1.41	2.42	18.92
	Rose	21.70	↑119.41	A*	0.39	21.12	22.20	1.78
Maritime pine	Control	7.78	-	IJ	0.62	6.50	8.29	7.99
	Blue	-3.06	↓139.33	P	0.22	-3.34	-2.65	-7.05
	Rose	18.41	↑136.63	C	0.95	16.99	19.50	5.13

Number of Measurements: 10, *: Highest result, **: Lowest result

The results for b* (yellow color tone) values are given in Table 8. In the measured b* parameter, decreases were observed with both varnish applications in all wood species except for black alder wood. Additionally, the decrease rates were consistently higher with the application of blue varnish compared to rose varnish. In black alder wood, a decrease of 63.52% was detected with the application of blue varnish, while an increase of 12.17% was noted with rose varnish. The highest result for the b* test was found in the untreated mulberry test samples (28.05), while the lowest b* parameter was observed in mahogany wood treated with blue varnish (3.91) (Table 8).

Table 8: Results for b* parameter

Wood Type	Type of Varnish	Mean	Change (%)	Homogeneity Group	Standard Deviation	Mini-mum	Maxi-mum	Coefficient of Variation
Mahogany	Control	13.96	-	K	0.35	13.43	14.77	2.53
	Blue	2.91	↓79.15	P**	0.25	2.45	3.25	8.57
	Rose	4.39	↓68.55	O	0.51	3.75	4.97	11.63
Ayous	Control	26.44	-	B	0.24	26.07	26.75	0.90
	Blue	9.97	↓62.29	L	0.43	9.29	10.57	4.34
	Rose	24.88	↓5.90	D	0.37	24.31	25.39	1.50
Mulberry	Control	28.05	-	A*	1.03	26.50	29.35	3.66
	Blue	9.65	↓65.60	L	0.48	8.77	10.25	4.98
	Rose	23.41	↓16.54	E	0.88	22.47	25.22	3.76
Persian silk	Control	26.52	-	B	0.37	26.16	27.32	1.40
	Blue	3.10	↓88.31	P	0.33	2.61	3.45	10.70
	Rose	25.04	↓5.58	CD	0.49	23.90	25.38	1.96
American walnut	Control	18.46	-	H	0.66	17.42	19.37	3.57
	Blue	5.11	↓72.32	N	0.27	4.71	5.72	5.26
	Rose	15.72	↓14.84	J	0.99	14.18	16.72	6.28
Russian olive	Control	21.95	-	G	0.66	20.62	22.87	3.01
	Blue	8.53	↓61.14	M	0.35	7.78	8.96	4.05
	Rose	17.39	↓20.77	I	1.67	15.43	20.10	9.58
Black alder	Control	22.59	-	F	0.55	22.07	23.69	2.42
	Blue	8.24	↓63.52	M	0.46	7.54	9.02	5.53
	Rose	25.34	↑12.17	CD	0.53	24.54	26.31	2.10
Maritime pine	Control	25.53	-	C	0.69	24.24	26.26	2.69
	Blue	4.51	↓82.33	O	0.17	4.20	4.73	3.84
	Rose	23.44	↓8.19	E	0.21	23.12	23.80	0.89
Number of Measurements: 10, *: Highest result, **: Lowest result								

The results for C* (chroma) values are presented in Table 9. The highest result for the C* value was found in the black alder test samples treated with rose varnish (33.35), while the lowest C* value was found in mahogany wood treated with blue varnish (3.10). Decreases in C* values were found in varnish applications on mahogany and Russian olive woods. In all other wood species, decreases were observed in the test samples coated with blue varnish (Persian silk 84.46% > Maritime pine 80.98% > American walnut 74.00% > mulberry 66.50% > black alder 64.69% > ayous 63.59%), while increases were detected in the wood samples coated with rose varnish (black alder 35.24% > Maritime pine 11.64% > Persian silk 11.25% > ayous 10.39% > mulberry 1.81% > American walnut 1.22%) (Table 9).

Table 9: Results for C* parameter

Wood Type	Type of Varnish	Mean	Change (%)	Homogeneity Group	Standard Deviation	Mini-mum	Maxi-mum	Coefficient of Variation
Mahogany	Control	18.31	-	K	0.40	17.87	19.02	2.17
	Blue	3.01	↓83.56	Q**	0.26	2.54	3.36	8.67
	Rose	6.42	↓64.94	N	0.92	5.41	7.62	14.33
Ayous	Control	27.44	-	E	0.27	27.01	27.78	1.00
	Blue	9.99	↓63.59	L	0.44	9.30	10.60	4.40
	Rose	30.29	↑10.39	CD	0.41	29.64	30.80	1.36
Mulberry	Control	30.39	-	BCD	1.00	28.95	31.74	3.30
	Blue	10.18	↓66.50	L	0.56	9.17	10.83	5.46
	Rose	30.94	↑1.81	B	0.16	30.75	31.20	0.50
Persian silk	Control	27.73	-	E	0.41	27.25	28.54	1.47
	Blue	4.31	↓84.46	P	0.22	3.99	4.56	5.15
	Rose	30.85	↑11.25	BC	0.49	30.10	31.61	1.58
American walnut	Control	19.73	-	J	0.66	18.75	20.64	3.35
	Blue	5.13	↓74.00	O	0.27	4.73	5.73	5.23
	Rose	19.97	↑1.22	J	1.24	18.12	21.25	6.22
Russian olive	Control	24.06	-	H	0.66	22.85	25.07	2.73
	Blue	9.01	↓62.55	M	0.40	8.11	9.48	4.47
	Rose	22.31	↓7.27	I	1.24	20.45	23.95	5.55
Black alder	Control	24.66	-	G	0.61	24.11	25.88	2.46
	Blue	8.46	↓65.69	M	0.46	7.86	9.21	5.39
	Rose	33.35	↑35.24	A*	0.39	32.76	33.86	1.15
Maritime pine	Control	26.71	-	F	0.80	25.26	27.54	2.98
	Blue	5.08	↓80.98	O	0.73	3.72	5.62	14.28
	Rose	29.82	↑11.64	D	0.63	28.83	30.60	2.10

Number of Measurements: 10, *: Highest result, **: Lowest result

The structural properties of varnish layers can vary depending on the components used in their formulation. Differences in the types and quantities of primary binders and other layer-forming agents are key factors contributing to these variations (Sönmez 1989).

The components of the varnish could chemically react with the different wood species used in the study, potentially causing changes in color tones, particularly in relation to pigments and binders.

In studies on varnish in the literature, it has been reported that the color parameters change with the applied varnishes (Mitan et al., 2019; Çamlıbel and Ayata, 2024; Altıparmak, 2017; Vardanyan et al., 2015; Ayata et al., 2024a; b; Bekhta et al., 2022; Gall et al., 2023; Ayata and Ayata, 2024; Ayata and Bal, 2024; Bila et al., 2020; Ulay, 2018).

3. Conclusions

Decreases were observed in the L* parameter across all wood species when applying two different types of varnish. For the a* parameter, decreases were detected with the application of two different colored varnishes on mahogany wood while in all other wood species, the application of blue varnish resulted in decreases, and the application of rose varnish resulted in increases. In the b* parameter, decreases were observed with both varnish applications in all wood species except for black alder wood. For the C* values, decreases were found in the varnish applications on mahogany and Russian olive woods. In all other wood species, decreases were observed in the test samples coated with blue varnish, while increases were noted in the wood samples coated with rose varnish. For the ho values, increases were obtained with the application of blue varnish across all wood species, while decreases were observed with the application of rose varnish. It is recommended that aging tests be conducted on these wood materials coated with different colored varnishes in future studies.

Disclosure Statement

No potential conflict of interest was reported by the authors.

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