# Application of Synthetic-based Furniture Varnish to Various Wood Species: Comparison of Color Parameters

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Synthetic-based furniture varnish (colorless and glossy) was applied in two coats using a brush to the following wood types: lemon (*Citrus limon* (L.) Burm.), black pine (*Pinus nigra* Arnold), kotibé (*Nesogordonia papaverifera*), iroko (*Milicia excelsa* Welw. C.C. Berg), and loquat (*Eriobotrya japonica* Lindl.). The color parameters [$b^*$, $h^o$, $L^*$, $a^*$, and $C^*$, $\Delta a^*$, $\Delta L^*$, $\Delta C^*$, $\Delta H^*$, $\Delta b^*$, and $\Delta E^*$] of the varnished and unvarnished surfaces were compared. The analysis of variance results for all color parameters revealed significant effects for wood type, varnish application, and their interaction. When the $\Delta E^*$ values derived from color formulas were sorted from the lowest to the highest, they were ordered as follows: lemon, black pine, kotibé, loquat, and iroko. After varnish application, decreases in $L^*$ values were observed across all wood types, while increases in $b^*$ and $C^*$ values were detected. In black pine wood, the $a^*$ and $h^o$ values increased. Additionally, for iroko, loquat, and kotibé woods, there was an increase in the $a^*$ parameter, while $h^o$ values decreased for these wood types. Overall, the varnish application resulted in color changes in the wood materials.

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## INTRODUCTION

Wood primarily comes from plants classified as gymnosperms, commonly known as conifers, and from angiosperms in the dicotyledon group, which are known as broad-leaved trees (Hägglund 1942; Nardi Berti 1994; Cecchini 2014). Exterior coatings applied to wood often have short lifespans or completely fail. This failure is usually due to using the wrong type of finish or not following the proper application techniques (Cassens and Feist 1988).

Several strategies are employed to prevent fungal decay in wood, such as impregnating the wood with biocides, modifying the wood itself, employing protective designs, selecting naturally durable wood species, and using hydrophobic treatments (Reinprecht 2016; Humar *et al*. 2020; Hodžić and Bahmani 2023).

The binder, also referred to as resin or polymer, is the core component of paints or varnishes. It can be natural or synthetic and comes in liquid, viscous, or solid form. The binder must have the capacity to form a uniform film when the paint or varnish is applied.

Beyond imparting optical qualities like color and opacity, the binder is responsible for all other characteristics of the dried product, making it a crucial part of the formulation (Nadji 2014).

Varnish can be defined as any liquid that does not contain suspended solids like pigments and is used to decorate or protect surfaces by forming a smooth, hard coating when it dries (Stratton 1917). Producing liquid varnish is a fairly straightforward process. A varnish product is made by blending various components in a way that ensures a balanced and homogeneous mixture. This blending is done in specific, repeated steps for each production batch, as varnishes are made in batch reactors rather than through continuous production lines (Paglia 2012).

Varnish is particularly vulnerable to damage from external factors. Natural resin-based varnishes can degrade at the molecular level due to photo-oxidation, leading to issues such as loss of clarity, yellowing, and changes in solubility (Maines and de la Rie 2005; Proctor and Whitten 2012; Bestetti 2020; Pieralli *et al*. 2023).

Since the early 1900s, a range of synthetic resins have been commercially produced. Some of the most frequently used resins in paints, varnishes, and lacquers include cellulosic, phenolic, alkyd, vinyl, acrylic, and methacrylic resins, as well as chlorinated rubber derivatives, styrene-butadiene, and silicone oils (Martens 1964; Krivanek 1982; Anonymous 1989).

Furniture varnishes necessitate a higher resin content and faster drying times. This is due to their inability to meet the wear demands of floor varnishes and the need for quick drying in furniture production settings. Moreover, they must be manageable for sanding and polishing to achieve a smooth, high-quality finish (Weaver 1948).

The literature includes studies comparing the results of color parameters on various wood types after applying different types of varnishes. Examples of such studies involve keranji, keruing, niové, rubber, and berangan woods (Çamlıbel and Ayata 2024), limba and chestnut (Altıparmak 2017), black locust (Ayata *et al*. 2024), beech and Scots pine (Koç 2023), and iroko and ash (Ulay 2018). These studies have reported different outcomes in their findings.

In this study, a synthetic-based furniture varnish was applied in two coats using a brush to the following wood types: lemon, kotibé, iroko, black pine, and loquat. The color parameters of the varnished surfaces were compared with those of the unvarnished surfaces for each wood type. The study aimed to reveal the effects of the varnish interacting with the wood materials.

## EXPERIMENTAL

Test samples of lemon (*Citrus limon* (L.) Burm.), black pine (*Pinus nigra* Arnold), kotibé (*Nesogordonia papaverifera*), iroko (*Milicia excelsa* Welw. C.C. Berg), and loquat (*Eriobotrya japonica* Lindl.) woods were prepared in dimensions of 100 mm x 100 mm x 20 mm. Conditioning treatments were applied to the samples (20±2 °C and 65% relative humidity) (ISO 554 1976).

Sanding operations were performed using a vibration sander with 80, 100, and 120 grit sandpapers. The surfaces of the varnished wood materials were cleaned of dirt, sanding dust, and oil. Care was taken to ensure the wood surfaces were neither damp nor wet. During this cleaning process, a pressure compressor was used after sanding.

In the study, synthetic-based furniture varnish from a specialized company was obtained through purchase. 10 samples were used for each group. The varnish is colorless, with a solid content of 48% and a specific gravity of 0.90 g/cm$^3$.

Before applying the varnish, the varnish was diluted with 10% synthetic thinner. Two coats were applied using a brush (application area: 10-12 m$^2$/l, drying time: dust-free drying in 8 h, hard drying in 24 h). This information constitutes the packaging specifications from the varnish manufacturer. The varnishing process was carried out as defined for industrial applications. The varnishing procedure adhered to the guidelines specified in ASTM-D 3023 (2017).

Color changes (parameters: $L^*$, $a^*$, $C^*$, $h^o$, and $b^*$) were measured using the CS-10 (CHN Spec, China) device [CIE 10° standard observer; CIE D65 light source, illumination system: 8/d (8°/diffused illumination)] (ASTM D 2244-3 2007). Ten measurements per group were taken, totaling 500 measurements.

The $L^*$ variable represents lightness or brightness, ranging from 0 (black) to 100 (white). The $a^*$ and $b^*$ variables express color coordinates and both range from -60 to +60. The angle between the $C^*$ axis and the $a^*$ axis is referred to as $h^o$ and indicates the hue angle. The $C^*$ variable denotes the color saturation or chromaticity value. In the CIE-*Lab** color diagram, positive and negative signs indicate the following: +$a^*$ signifies an increase in red, -$a^*$ signifies an increase in green, +$b^*$ signifies an increase in yellow, and -$b^*$ signifies an increase in blue (Konica Minolta 2014; Mesquita *et al*. 2023).

$\Delta C^*$ is defined as the difference in chroma or saturation, and $\Delta H^*$ is defined as the difference in hue or shade (Lange 1999).

The results for total color differences ($\Delta a^*$, $\Delta L^*$, $\Delta C^*$, $\Delta H^*$, $\Delta b^*$, and $\Delta E^*$) were determined using the following formulas.

$$C^* = [(a^*)^2 + (b^*)^2]^{0.5} \quad (1)$$

$$h^o = \arctan\,(b^*/a^*) \quad (2)$$

$$\Delta C^* = (C^*_{\text{experimental example with varnish application}} - C^*_{\text{test sample without varnish application}}) \quad (3)$$

$$\Delta a^* = (a^*_{\text{experimental example with varnish application}} - a^*_{\text{test sample without varnish application}}) \quad (4)$$

$$\Delta L^* = (L^*_{\text{experimental example with varnish application}} - L^*_{\text{test sample without varnish application}}) \quad (5)$$

$$\Delta b^* = (b^*_{\text{experimental example with varnish application}} - b^*_{\text{test sample without varnish application}}) \quad (6)$$

$$\Delta H^* = [(\Delta E^*)^2 - (\Delta L^*)^2 - (\Delta C^*)^2]^{0.5} \quad (7)$$

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{0.5} \quad (8)$$

Additionally, definitions for other parameters are provided in Table 1 (Lange 1999), and comparison criteria for $\Delta E^*$ are given in Table 2 (DIN 5033 1979).

**Table 1.** Definitions of $\Delta b^*$, $\Delta L^*$, $\Delta a^*$, and $\Delta C^*$ values (Lange 1999)

| Parameter | In positive case | In negative condition |
|---|---|---|
| $\Delta L^*$ | Lighter than reference | Darker than reference |
| $\Delta a^*$ | Redder than reference | Greener than reference |
| $\Delta b^*$ | Yellower than reference | Bluer than reference |
| $\Delta C^*$ | Clearer, brighter than reference | Matte, more blurred than reference |

**Table 2.** Comparison Criteria for Δ*E** (DIN 5033 1979)

| Total color difference (Δ*E**) | Visual color score difference |
|---|---|
| <0.2 | Not perceptible |
| 0.2 - 0.5 | Very weak |
| 0.5 - 1.5 | Weak |
| 1.5 - 3.0 | Noticeable |
| 3.0 - 6.0 | Very noticeable |
| 6.0 - 12.0 | Strong |
| > 12.0 | Very strong |

Standard deviations, maximum and minimum values, average values, homogeneity groups, variance analyses, and percentage (%) change were calculated using a statistical software program.

## RESULTS AND DISCUSSION

The results for color parameters [*b** (yellow color tone), *h*° (hue angle), *L** (lightness), *a** (red color tone), and *C** (chroma)] are presented in Table 3.

For all wood types, varnish application resulted in a decrease in *L** values. This decrease was observed in the following order from greatest to smallest: iroko (21.52%) > loquat (15.1%) > kotibé (12.8%) > black pine (3.9%) > lemon (0.6%). In the *L** test, unvarnished samples showed higher *L** values than their varnished counterparts. Lemon wood had the highest *L** value (76.5), which is consistent with its light yellow color. Conversely, varnished iroko wood had the lowest *L** value (43.5) (Table 3).

For the *a** value, varnish application resulted in a 13.6% decrease in lemon wood, while increases were observed in other wood types (loquat: 76.0%, iroko: 69.0%, kotibé: 22.9%, and black pine: 16.7%). The highest *a** value was found in varnished kotibé wood (16.9), while the lowest *a** value was observed in varnished lemon wood (5.7) (Table 3).

The highest *b** value was recorded for varnished black pine wood (29.0), while the lowest was for unvarnished loquat wood (16.0). Increases in *b** values were observed, ranked from highest to lowest as follows: loquat (28.9%) > black pine (20.8%) > lemon (10.1%) > kotibé (9.6%) > iroko (5.5%) (Table 3).

Increases in *C** values have been observed. Increases in *C** values were noted, with the rankings from highest to lowest as follows: loquat (39.5%) > black pine (20.3%) > kotibé (15.0%) > iroko (14.4%) > lemon (8.7%). For the *C** parameter, the highest value was found in varnished black pine wood (31.2), while the lowest *C** value was observed in unvarnished loquat wood (17.8) (Table 3).

The highest value for the *h*° parameter was recorded in varnished lemon wood (78.2), while the lowest value was observed in varnished kotibé wood (52.6). The application of varnish resulted in a decrease in the *h*° parameter for iroko (11.3%), kotibé (5.1%), and loquat (11.9%) woods, while an increase was observed for lemon (4.1%) and black pine (1.0%) (Table 3).

In the study conducted by Ayata *et al*. (2024), reductions in $L^*$, $b^*$, $h^o$, and $C^*$ values were observed following the application of yacht varnishes on mahogany and sipo wood species. While increases in $a^*$ values were observed in sipo wood, decreases in $a^*$ values were found in mahogany wood. In the research by Çamlıbel and Ayata (2024), the application of a solvent-based acrylic resin varnish on rubber, keruing, keranji, niové, and berangan woods resulted in reductions in $h^o$ and $L^*$ values, while increases were observed in $a^*$ and $C^*$ values. Furthermore, $b^*$ values decreased in rubber wood, whereas increases were noted in niové, keranji, keruing, and berangan woods. In Ayata *et al*.'s (2024b) research, yacht varnish applied to black locust wood resulted in lower $L^*$ and $h^o$ values, whereas $C^*$, $b^*$, and $a^*$ parameters showed increases.

The use of synthetic-based furniture varnish led to alterations in the color parameters of the wood materials. The measurements taken, along with the SPSS analyses, validated that these changes are precise and reliable. The study successfully met its objectives.

The color change in wood material following varnish application has been addressed by several researchers in the literature. For example, Çakıcıer (2007) found that Scots pine contains more extractives than other wood species, and this leads to significant color changes due to oxidation when exposed to water-based varnishes with alkaline properties (pH 8-9). In a study conducted by Bilgen (2010), it was reported that the yellow color value of the samples increased in direct proportion to the angle of the light hitting the surface, and this increase in the yellow color value could be due to some fading of the color. In addition, it was noted that as a result of the heating of the sample surface, the structure of the resins and waxes used in the production of synthetic-based glass varnish was altered, leading to an increase in the red color value on the samples. Similarly, Kesik (2009) pointed out in his study that species such as iroko and sessile oak, which have tannins in their cell walls, can experience color darkening as a result of the interaction between tannins and water-soluble varnishes. This should be taken into consideration when applying varnish to such woods.

Varnish samples can display a range of colors that transition dramatically from yellow on the outside to red and eventually brown in the center. These variations in color suggest that the varnish may not have a uniform chemical composition, and the presence of multiple colors could provide meaningful insights (Sniderman 2015). The structural characteristics of varnish layers can differ due to the components used in their production. Variations in the types and amounts of primary binders and additional layer-forming agents play a significant role in creating these differences (Sönmez 1989).

The constituents of the varnish might chemically interact with the various wood types utilized in the study, potentially resulting in variations in color tones, especially regarding pigments and binders.

The presence of open pores, such as fiber lumens (softwoods) and vessel pores (hardwoods) results in the scattering of light, which tends to increase the $L^*$ value. But application of varnish fills some of those pores with material that has a refractive index similar to that of the wood. This results in a decrease in light scattering. As a consequence, the $L^*$ value is lower and the wood appears richer in color. In other words, there will be a general trend for the $a^*$ and $b^*$ values to be farther away from zero with more resin filling pores near to the wood surface due to there being less scattering of light.

**Table 3.** The Results for the Color Parameters ($b^*$, $h^o$, $L^*$, $a^*$, and $C^*$)

| Test | Wood Type | Varnish Application | Mean | Change Ratio (%) | *HG* | Standard Deviation | Mini-mum | Maxi-mum | COV |
|---|---|---|---|---|---|---|---|---|---|
| *L** | Iroko | No | 55.38 | ↓21.52 | E | 0.52 | 54.64 | 56.01 | 0.94 |
| | | Yes | 43.46 | | H** | 0.92 | 41.05 | 44.27 | 2.12 |
| | Black Pine | No | 67.43 | ↓3.89 | B | 0.91 | 65.78 | 68.58 | 1.35 |
| | | Yes | 64.81 | | C | 0.63 | 63.38 | 65.66 | 0.97 |
| | Kotibé | No | 50.76 | ↓12.75 | F | 0.80 | 49.47 | 52.01 | 1.57 |
| | | Yes | 44.29 | | G | 1.31 | 41.97 | 45.48 | 2.95 |
| | Lemon | No | 76.53 | ↓0.56 | A* | 0.78 | 75.23 | 77.58 | 1.02 |
| | | Yes | 76.10 | | A | 0.77 | 74.75 | 76.78 | 1.01 |
| | Loquat | No | 60.21 | ↓15.08 | D | 0.60 | 59.52 | 61.02 | 0.99 |
| | | Yes | 51.13 | | F | 0.21 | 50.81 | 51.53 | 0.41 |
| *a** | Iroko | No | 8.40 | ↑69.05 | F | 0.33 | 7.94 | 8.86 | 3.89 |
| | | Yes | 14.20 | | B | 0.23 | 13.86 | 14.52 | 1.63 |
| | Black Pine | No | 9.69 | ↑16.72 | E | 0.54 | 8.68 | 10.60 | 5.53 |
| | | Yes | 11.31 | | D | 0.48 | 10.61 | 12.40 | 4.20 |
| | Kotibé | No | 13.75 | ↑22.91 | C | 0.59 | 12.70 | 14.34 | 4.26 |
| | | Yes | 16.90 | | A* | 0.48 | 16.21 | 17.64 | 2.86 |
| | Lemon | No | 6.60 | ↓13.64 | H | 0.29 | 6.22 | 7.20 | 4.38 |
| | | Yes | 5.70 | | I** | 0.17 | 5.32 | 5.95 | 2.96 |
| | Loquat | No | 7.78 | ↑75.96 | G | 0.29 | 7.41 | 8.18 | 3.69 |
| | | Yes | 13.69 | | C | 0.16 | 13.45 | 13.95 | 1.14 |
| *b** | Iroko | No | 23.69 | ↑5.49 | D | 0.15 | 23.43 | 24.00 | 0.65 |
| | | Yes | 24.99 | | C | 0.94 | 22.71 | 26.01 | 3.75 |
| | Black Pine | No | 24.02 | ↑20.82 | D | 0.71 | 22.28 | 24.74 | 2.94 |
| | | Yes | 29.02 | | A* | 0.45 | 28.39 | 29.69 | 1.55 |
| | Kotibé | No | 19.92 | ↑9.59 | G | 0.50 | 18.91 | 20.67 | 2.51 |
| | | Yes | 21.83 | | E | 1.93 | 16.96 | 23.09 | 8.82 |
| | Lemon | No | 24.85 | ↑10.10 | C | 0.95 | 23.66 | 26.60 | 3.81 |
| | | Yes | 27.36 | | B | 0.71 | 26.62 | 28.59 | 2.61 |
| | Loquat | No | 16.04 | ↑28.93 | H** | 0.17 | 15.73 | 16.35 | 1.08 |
| | | Yes | 20.68 | | F | 0.21 | 20.27 | 20.97 | 1.02 |
| *C** | Iroko | No | 25.14 | ↑14.40 | EF | 0.24 | 24.74 | 25.54 | 0.95 |
| | | Yes | 28.76 | | B | 0.81 | 26.95 | 29.76 | 2.83 |
| | Black Pine | No | 25.90 | ↑20.31 | D | 0.83 | 23.91 | 26.91 | 3.20 |
| | | Yes | 31.16 | | A* | 0.46 | 30.50 | 31.81 | 1.46 |
| | Kotibé | No | 24.21 | ↑14.99 | G | 0.52 | 23.20 | 24.71 | 2.14 |
| | | Yes | 27.84 | | C | 0.86 | 26.29 | 28.70 | 3.09 |
| | Lemon | No | 25.71 | ↑8.67 | DE | 0.98 | 24.50 | 27.56 | 3.82 |
| | | Yes | 27.94 | | C | 0.71 | 27.15 | 29.17 | 2.55 |
| | Loquat | No | 17.83 | ↑39.48 | H** | 0.24 | 17.39 | 18.20 | 1.36 |
| | | Yes | 24.87 | | F | 0.33 | 24.51 | 25.70 | 1.34 |
| *h°* | Iroko | No | 70.48 | ↓14.33 | C | 0.60 | 69.57 | 71.27 | 0.86 |
| | | Yes | 60.38 | | F | 1.08 | 57.40 | 60.98 | 1.79 |
| | Black Pine | No | 68.03 | ↑0.98 | D | 0.70 | 66.79 | 68.96 | 1.03 |
| | | Yes | 68.70 | | D | 0.86 | 67.05 | 69.83 | 1.25 |
| | Kotibé | No | 55.38 | ↓5.11 | H | 1.35 | 53.27 | 57.68 | 2.45 |
| | | Yes | 52.55 | | I** | 2.09 | 48.15 | 54.21 | 3.97 |
| | Lemon | No | 75.12 | ↑4.14 | B | 0.31 | 74.79 | 75.61 | 0.41 |
| | | Yes | 78.23 | | A* | 0.34 | 77.70 | 78.70 | 0.43 |
| | Loquat | No | 64.11 | ↓11.87 | E | 0.76 | 62.76 | 65.21 | 1.18 |
| | | Yes | 56.50 | | G | 0.43 | 55.79 | 57.19 | 0.76 |

COV: coefficient of variation, *HG*: homogeneity group, *: highest value, **: lowest value

The graphical representation of the results for color parameters is presented in Fig. 1.

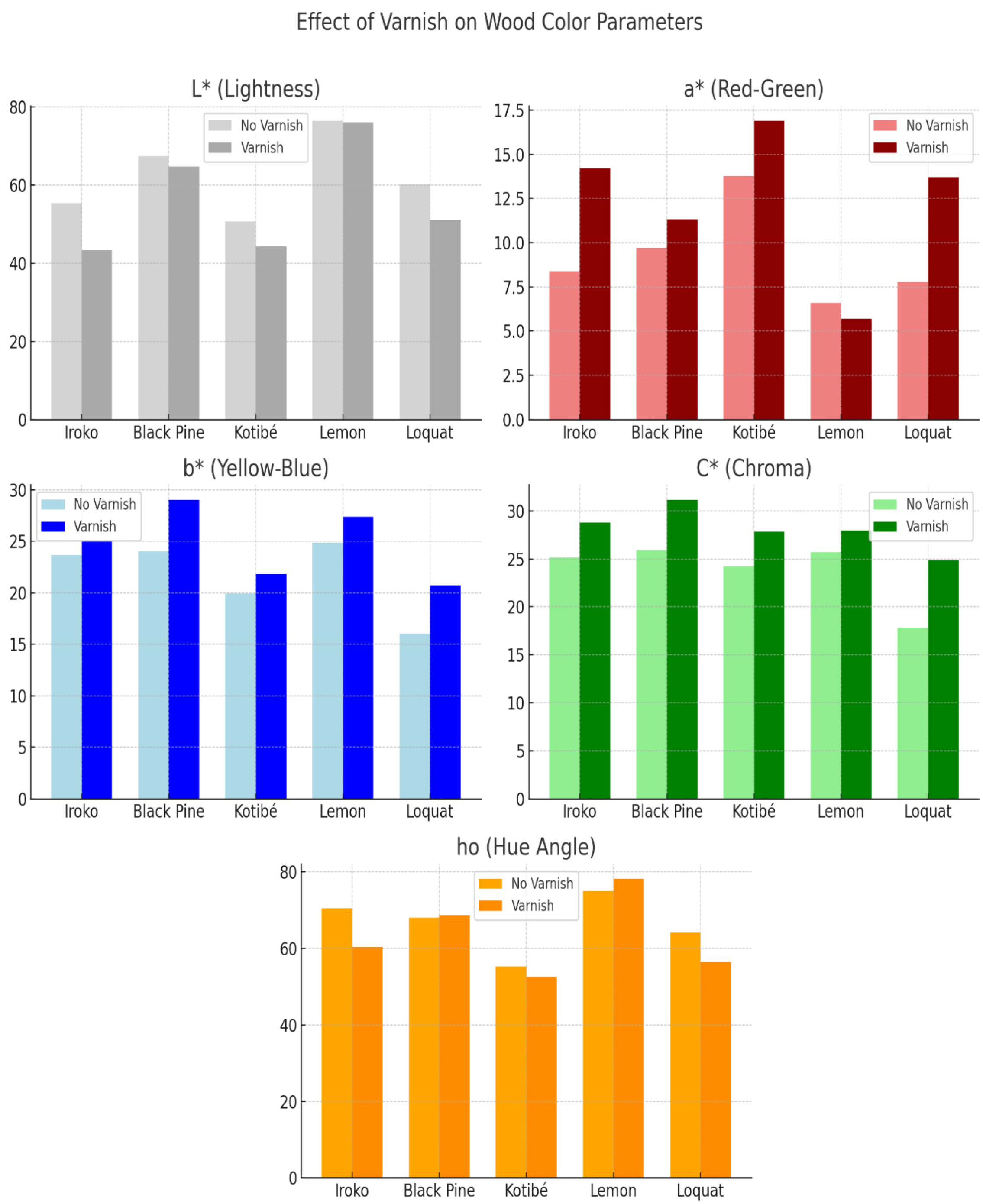


**Fig. 1.** Graphical representation of the results for color parameters

The results of the variance analysis for the color parameters are presented in Table 4. The wood type (A), varnish application (B), and interaction (AB) were found to be statistically significant (Table 4).

**Table 4.** Results of the Variance Analysis for the Color Parameters

| Test | Source | Mean Square | Sum of Squares | Degrees of Freedom | F Value | α≤0.05 |
|---|---|---|---|---|---|---|
| *L** | Wood type (A) | 11701.254 | 4 | 2925.314 | 4643.906 | 0.000* |
| | Application (B) | 930.555 | 1 | 930.555 | 1477.247 | 0.000* |
| | Interaction (AB) | 436.162 | 4 | 109.041 | 173.101 | 0.000* |
| | Error | 56.693 | 90 | 0.630 | | |
| | Total | 361341.495 | 100 | | | |
| | Corrected total | 13124.665 | 99 | | | |
| *a** | Wood type (A) | 848.766 | 4 | 212.191 | 1443.356 | 0.000* |
| | Application (B) | 242.643 | 1 | 242.643 | 1650.491 | 0.000* |
| | Interaction (AB) | 166.989 | 4 | 41.747 | 283.970 | 0.000* |
| | Error | 13.231 | 90 | 0.147 | | |
| | Total | 12940.165 | 100 | | | |
| | Corrected total | 1271.628 | 99 | | | |
| *b** | Wood type (A) | 991.871 | 4 | 247.968 | 352.155 | 0.000* |
| | Application (B) | 236.052 | 1 | 236.052 | 335.234 | 0.000* |
| | Interaction (AB) | 55.212 | 4 | 13.803 | 19.603 | 0.000* |
| | Error | 63.373 | 90 | 0.704 | | |
| | Total | 55348.833 | 100 | | | |
| | Corrected total | 1346.509 | 99 | | | |
| *C** | Wood type (A) | 592.254 | 4 | 148.063 | 347.045 | 0.000* |
| | Application (B) | 474.020 | 1 | 474.020 | 1111.052 | 0.000* |
| | Interaction (AB) | 67.883 | 4 | 16.971 | 39.778 | 0.000* |
| | Error | 38.398 | 90 | 0.427 | | |
| | Total | 68431.865 | 100 | | | |
| | Corrected total | 1172.554 | 99 | | | |
| *h*° | Wood type (A) | 5831.678 | 4 | 1457.920 | 1467.879 | 0.000* |
| | Application (B) | 280.965 | 1 | 280.965 | 282.884 | 0.000* |
| | Interaction (AB) | 610.296 | 4 | 152.574 | 153.616 | 0.000* |
| | Error | 89.389 | 90 | 0.993 | | |
| | Total | 428615.816 | 100 | | | |
| | Corrected total | 6812.328 | 99 | | | |
| *: Significant | | | | | | |

The results for total color differences (Δ*a**, Δ*L**, Δ*C**, Δ*H**, Δ*b**, and Δ*E**) are presented in Table 5.

When the Δ*E** values, calculated using color formulas, are arranged from smallest to largest, they are 2.70 for lemon, 5.88 for black pine, 7.44 for kotibé, 11.78 for loquat, and 13.32 for iroko. With varnish application, Δ*L** values for all wood types were obtained as negative (darker than reference), while Δ*b** and Δ*C** values were positive (respectively: yellower than reference and clearer, brighter than reference). The Δ*a** value was found to be negative (greener than reference) for lemon wood, while it was positive (redder than reference) for all other wood types (Table 5).

Additionally, Δ*H** values were calculated for all wood types using the positive square root values (1.46 for lemon, 0.29 for black pine, 0.62 for kotibé, 2.63 for loquat, and 4.72 for iroko). When comparing the results with the color change criteria (DIN 5033 1979), the values obtained are as follows: lemon falls into the "noticeable (1.5 to 3.0)" category, black pine into the "very noticeable (3.0 to 6.0)" category, kotibé and loquat into the "strong (6.0 to 12.0)" category, and iroko into the "very strong (> 12.0)" category (Table 5). In their study, Söğütlü and Sönmez (2006) reported that a decrease in gloss values could indicate a darkening of the color tone, while an increase in gloss may suggest a lightening of the color. This time the point that needs to be made is that the different species of wood have differences in the sizes of pores, the permeability of the wood, and the porosity (fractional void volume). Because of these differences one can expect there to be differences in the extent to which permeation of the varnish resin into the pores will affect the *L** values and the depth of coloration.

**Table 5.** The Results for Total Color Differences (Δ*a**, Δ*L**, Δ*C**, Δ*H**, Δ*b**, and Δ*E**)

| Wood Type | Δ*L** | Δ*a** | Δ*b** | Δ*C** | Δ*H** | Δ*E** | Color Change Criteria (DIN 5033 1979) |
|---|---|---|---|---|---|---|---|
| Lemon | -0.42 | -0.90 | 2.51 | 2.23 | 1.46 | 2.70 | Noticeable (1.5 to 3.0) |
| Black pine | -2.62 | 1.62 | 5.01 | 5.25 | 0.29 | 5.88 | Very noticeable (3.0 to 6.0) |
| Kotibé | -6.46 | 3.15 | 1.91 | 3.63 | 0.62 | 7.44 | Strong (6.0 to 12.0) |
| Loquat | -9.08 | 5.91 | 4.65 | 7.04 | 2.63 | 11.78 | |
| Iroko | -11.92 | 5.81 | 1.29 | 3.62 | 4.72 | 13.32 | Very strong (> 12.0) |

## CONCLUSIONS

1. The aim of the study was to determine the color changes after the varnish was applied to 5 different types of wood and to compare the existing differences by detecting them with a color measuring device. The study has achieved its objective. The synthetic-based furniture varnish used in the study resulted in changes in color parameters of the wood materials. The measurements and subsequent SPSS calculations confirmed that these changes are accurate and valid. The results from the study on synthetic-based furniture varnish suggest that lemon wood should be used if a slight color change is preferred among the wood species treated with varnish. On the other hand, if a substantial color change is desired, iroko wood is recommended.
2. Each type of varnish contains different chemical components, which can affect the color and texture of the wood. Additionally, these components can produce varying results for different color parameters, leading to different tones on each type of wood. It is recommended to conduct natural or artificial aging tests (such as xenon lamp tests, UV-A, UV-B, or UV-C lamp tests, and salt spray corrosion tests) on the varnished materials to subsequently calculate any color changes that may occur.

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