Effects of Artificial Weathering on the Color, Gloss, Adhesion, and Pendulum Hardness of UV System Parquet Varnish Applied to Doussie (*Afzelia africana*) Wood

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An important wood species in the furniture and parquet industry today is "doussie" wood. In this study, the effects of artificial weathering on ultraviolet-cured varnish (3 coats and 5 coats) applied to doussie (*Afzelia africana*) wood were investigated. The samples of the UV system cured varnishes were exposed to aging effects for 252 h and 504 h *via* an UV-A 340 nm lamp. The coated specimens were exposed to UV-A 340 nm fluorescent lamp in a QUV accelerated weathering tester for 252 h and 504 h. The surface adhesion strength, color (L^*, a^*, b^*, ΔE^*, ΔL^*, Δa^*, and Δb^*) parameters, pendulum hardness, and glossiness (parallel (//) and perpendicular (⊥) at 20°, 60°, and 85°) of UV varnishes coated samples were quantified before and after weathering. According to the results, while the a^* value increased, the adhesion, L^*, b^*, and glossiness values decreased with aging. As a result, it was concluded that doussie wood can be used in the production of flooring with UV-cured varnish.

Keywords: Afzelia africana; UV system varnish; Glossiness; Color; Pendulum hardness; Adhesion

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INTRODUCTION

Doussie *(Afzelia africana*) wood is a durable general-utility timber used locally for outdoor and indoor construction, cabinet making, and railway ties. This wood is suitable for parquet flooring, solid doors, stair treads, and general joinery (Chalk *et al*. 1933). *Afzelia africana* wood has the following characteristics: Pale straw sapwood sharply defined from reddish brown heartwood. The grain is irregular, often interlocked, and has a coarse but even texture (Lincoln 1986), a vessel diameter of 200 µm to 235 µm, a fibre length of 800 µm to 1300 µm, a fibre diameter of 100 µm to 130 µm, a ray height of 230 µm to 330 µm, 25 to 36 cells/rays, ray width of 2 cell to 3 cell (Jayeola *et al*. 2009), a density of 823.81 kg/m^3, a volume shrinkage of 7.57%, a volume swelling of 7.50%, a specific gravity of 0.84%, a modulus of rupture (MOR) of 136.71 N/mm^2, a modulus of elasticity (MOE) of 6313.58 N/mm^2 (Jamala *et al*. 2013), and a total weight loss after being kept in sea water for 1 y of 34.83% (Şen and Yalçin 2010).

There are a limited number of studies on parquet varnish for various species. The following studies can be cited: Northern red oak (*Quercus rubra*), American black walnut (*Juglans nigra*), maple (*Acer pseudoplatanus* L.), and walnut (*Juglans regia*) were studied by Ayata *et al*. (2018), rowan (*Sorbus* L.) was studied by Gurleyen *et al*. (2017b), oak (*Quercus petraea* L.) was studied by Gurleyen *et al.* (2019), limba (*Terminalia superba*), chestnut (*Castanea sativa* Mill.), sapele (*Entandrophragma cylindricum*), iroko

(*Chlorophora excelsa*) were studied by Ayata and Cavus (2018), Scotch pine (*Pinus sylvestris* L.) was studied by Gurleyen *et al*. (2017c), ash (*Fraxinus excelsior*) (heat-treated at 212 °C for 2 h) was studied by Ayata *et al*. (2017b), beech (*Fagus orientalis* Lipsky.) was studied by Ayata *et al*. (2017a), and lemon (*Citrus limon* (L.) Burm.) was studied by Ayata (2019).

In these studies, the relationship between the wood material and a UV system varnish was evaluated by various tests (color, gloss, oscillating hardness, surface adhesion resistance, *etc*.). Various chemicals (clear UV curing hydro primer, UV curtain coating high gloss, clear mat UV oil, *etc*.) are used in the UV system industries to ensure that the UV system varnish layer has a high resistance to physical effects, chemical conditions, abrasion, and UV rays.

Learning the condition of the produced parquet after exposure to environmental conditions provides information about the life of the material. Although it is known in the literature that doussie wood is an important type of wood in the furniture and parquet industry, there is no information regarding its usage in UV system parquet production.

Doussie wood is a valuable wood species in the furniture industry. It is a hard wood (Jamala *et al.* 2013) and is a preferred and admired wood type in terms of texture, pattern, and color. For this reason, this wood type was preferred for the widespread use of the UV system in the parquet industry.

The paper reports the changes in the surface adhesion resistance, colour (L^*, a^*, b^*, ΔL^*, Δa^*, Δb^*, and ΔE^*), pendulum hardness (könig), and glossiness parallel (//) and perpendicular (⊥) to the grain at 20°, 60°, and 85° angles of doussie (*Afzelia africana*) wood coated with 3 layers and 5 layers of a UV system varnish before and after weathering (252 h and 504 h).

EXPERIMENTAL

Wood Material

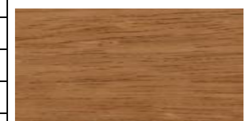
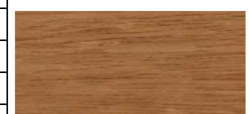
Doussie (*Afzelia africana*) wood was purchased from Arın Forest Products Company located in Duzce City, Turkey. Wood samples with dimensions of 80 cm × 11 cm × 1.9 cm (longitudinal × tangential × radial) were prepared. Then, air conditioning processes were applied to the wood samples (a relative humidity of 65% ± 3% and a temperature of 20 °C ± 2 °C), according to TS standard 2471 (1976).

Application of UV System Parquet Varnish

In this study, doussie wood was cut to 70 cm x 10 cm x 1.6 cm samples. The UV system varnishes (3 coats and 5 coats) were applied to the doussie samples, according to industrial application methods used at the KPS Company (Duzce City, Turkey).

The production methods of the UV system varnishes (3 coats and 5 coats) are given in Table 1. The contents of the chemicals used in this study were clearly explained in Ayata's (2019) study. UV system varnish applied samples were conditioned to 12% equilibrium moisture content in a special room at 20 ± 2°C and 65 ± 5% relative humidity (TS 2471, 1976).

Table 1. UV Varnish Application Methods (3 and 5 Coats)

Number of Coats	Process Steps	Varnish Sample
3	Sanding and calibrating machines (80 grit to 120 grit sizes)	
	Clear UV curing hydro primer applied to 10 g/m^2 then dried (70 °C)	
	UV curtain coating high gloss applied 8 g/m^2	
	UV lamp drying (2 times) Total (177 mJ/cm^2)	
	Sanding and calibrating machines (280 grit to 320 grit sizes)	
	Clear mat UV oil applied (8 g/m^2)	
	UV lamp drying (71 mJ/cm^2)	
	Clear mat UV oil to be applied (8 g/m^2)	
	UV lamp drying Total (2 times) (314 mJ/cm^2)	
5	Sanding and Calibrating Machines (80 grit to 120 grit sizes)	
	Clear UV curing hydro primer applied to 10 g/m^2 then dried (70 °C)	
	*UV clear curing sealer applied to 20 g/m^2 then dried (70 °C)	
	UV clear curing sealer applied to 10 g/m^2 then dried (70 °C)	
	UV clear curing sealer applied to 10 g/m^2 then dried (170 °C)	
	Sanding and Calibrating Machines (280 grit to 320 grit sizes)	
	Clear mat UV oil applied (8 g/m^2)	
	UV lamp drying (71 mJ/cm^2)	
	Clear mat UV oil applied (8 g/m^2)	
	UV lamp drying Total (2 times) (314 mJ/cm^2)	
UV system varnish production line speed of 10 m/min		

Methods

Artificial weathering

In the literature (Bulcke *et al.* 2008; Nzokou *et al.* 2011; Cakicier *et al.* 2015, 2011), a standard is used in UV aging applications in performance tests of varnishes used in interior spaces. In this study, the same processes were applied on the parquet with the interior material. An attempt was made to determine the useful life of the parquet material produced by aging, according to aging standard.

Samples coated with UV system varnishes (3 coats and 5 coats) were exposed in a QUV weathering tester (Q-Lab, Westlake, OH), according to ISO standard 4892-3 (2016) (a light intensity of 0.67, 15 min water spray, 8 h of ultraviolet exposure with UVA-340 lamps, and a temperature of 50 °C) for either 252 h or 504 h.

Determination of color measurement

The yellow color (b^*) tone, red color (a^*) tone, and lightness (L^*) of specimens was determined using a CS-10 colorimeter (CHN Spec, Hangzhou City, China) with a CIE 10° standard observer; CIE D65 light source, and 8°/diffused illumination, according to ASTM standard D 2244-07 (2007).

The CIELAB system, characterized by the three axes L^*, a^*, and b^*, was used. The L^* axis represents lightness, varying from 100 (white) to 0 (black), a^* is the red (+) to green (–) tone, and b^* is the yellow (+) to blue (–) tone (Ayata 2019). The corresponding changes in the total color difference (ΔE^*) and the Δa^*, ΔL^*, and Δb^* after applying 3 coats or 5 coats of UV system varnish to the wood samples were determined using Eqs. 1 through 4,

$$\Delta a^* = a^*_{\text{aged coated}} - a^*_{\text{unaged coated}} \quad (1)$$

$$\Delta L^* = L^*_{\text{aged coated}} - L^*_{\text{unaged coated}} \quad (2)$$

$$\Delta b^* = b^*_{\text{aged coated}} - b^*_{\text{unaged coated}} \quad (3)$$

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

where the variables are as defined by the CIELAB system.

Determination of glossiness measurement

Surface glossiness measurements were performed on the different layers of the UV system that was applied to the aged and unaged doussie samples, according to ISO standard 2813 (1994), with an ETB-0833 gloss meter (Vetus Electronic Technology Co., Ltd., Hefei, China). These measurements were carried out in the parallel (//) and perpendicular (⊥) direction at angles of 20º, 60°, and 85°.

Determination of pendulum hardness

The hardness of the varnish layers is an important indicator in determining its resistance against external influences. The device determines the layer hardness according to the swinging pendulum oscillations of two balls with a hardness of 63 HRC ± 3.3 HRC and a diameter of 5 mm ± 0.0005 mm on the sample surface placed on the platform (Sonmez 1989). The pendulum hardness of the unaged and aged doussie samples with 3 layers and 5 layers of UV system varnish was determined with a König device (Pendulum Damping Tester, Model 299/300 Erichsen, Hemer, Germany), in accordance to ASTM D standard 4366 (1995).

Determination of surface adhesion strength

The surface adhesion strength of the unaged and aged samples (10 cm x 10 cm x 1.6 cm) coated with 3 layers and 5 layers of UV system varnish were tested with a PosiTest AT-A (automatic) pull-off Adhesion Tester (DeFelsko Corporation, Ogdensburg, NY) according to ASTM standard D 4541 (1995). At room temperature (20 °C), cylinders with a 20 mm diameter were attached to the sample surfaces using 404 Fast Plastic Steel glue (404 Kimya ve Sanayi Ticaret A.Ş., Çekmeköy, Istanbul, Turkey), which is composed of 2,4,6-tris (dimethylaminomethyl) phenol and fixed with tools which were used for all coated samples. All test specimens were air-dried for 24 h, after which the glue residue was removed with a cutter. The adhesion X (MPa) was calculated using Eq. 5,

$$X = 4F / \pi . d^2 \quad (5)$$

where F is the rupture force (N) and d is the diameter of the experiment cylinder (mm) (Ayata 2014; Gurleyen *et al*. 2019).

Statistical analysis

In this study, there were 5 duplicates for each test sample type. The homogeneity groups, standard deviations, minimum and maximum values, average, and analysis of variance were determined, using the glossiness, color, pendulum hardness, and adhesion strength data obtained before and after weathering using the SPSS program (IBM, Armonk, NY).

Samples measuring 100 mm by 100 mm by 20 mm were used for all tests. Statistical analysis was performed for a total of 2790 measurements (glossiness (1800) + pendulum hardness (60) + color properties (900) + surface adhesion strength (30) = 2790).

RESULTS AND DISCUSSION

The results of the variance analysis (as shown in Table 2) demonstrated that the layer thickness (*A*), weathering period (*B*), and the interaction (*AB*) between these variables were all significant in terms of the change in the *L**, *b**, *a**, glossiness levels (parallel (//) and perpendicular (⊥) to the grain at 20°, 60°, and 85° angles), and pendulum hardness values (α is less than or equal to 0.05). In addition, according to the surface adhesion test, factor (*A*) and factor (*B*) were found to be significant, but the interaction between the two factors (*AB*) was found to be insignificant.

Table 2. Results of the Multiple Variance Analysis (ANOVA)

Test	Source of Variation	Sum of Squares	DF	Mean Square	F Number	Level of Sig
*L**	Layer thickness (A)	823.894	1	823.894	2438.665	0.000*
	Weathering period (B)	9452.387	2	4726.194	13989.187	0.000*
	Interaction (AB)	1475.220	2	737.610	2183.272	0.000*
	Error	99.327	294	0.338	-	-
	Total	521364.675	300	-	-	-
*a**	Layer thickness (A)	126.516	1	126.516	638.482	0.000*
	Weathering period (B)	1985.028	2	992.514	5008.868	0.000*
	Interaction (AB)	119.756	2	59.878	302.183	0.000*
	Error	58.256	294	0.198	-	-
	Total	130113.903	300	-	-	-
*b**	Layer thickness (A)	2155.846	1	2155.846	18938.483	0.000*
	Weathering period (B)	5555.071	2	2777.536	24399.850	0.000*
	Interaction (AB)	1161.543	2	580.771	5101.909	0.000*
	Error	33.467	294	0.114	-	-
	Total	110996.790	300	-	-	-
//20°	Layer thickness (A)	47.362	1	47.362	7554.507	0.000*
	Weathering period (B)	47.734	2	23.867	3806.943	0.000*
	Interaction (AB)	27.329	2	13.665	2179.564	0.000*
	Error	1.843	294	0.006	-	-
	Total	251.800	300	-	-	-
//60°	Layer thickness (A)	4816.815	1	4816.815	458744.257	0.000*
	Weathering period (B)	3189.629	2	1594.814	151887.089	0.000*
	Interaction (AB)	1623.159	2	811.579	77293.267	0.000*
	Error	3.087	294	0.011	-	-
	Total	23429.990	300	-	-	-
//85°	Layer thickness (A)	14851.589	1	14851.589	62354.225	0.000*
	Weathering period (B)	5905.078	2	2952.539	12396.202	0.000*
	Interaction (AB)	1502.201	2	751.100	3153.486	0.000*
	Error	70.025	294	0.238	-	-
	Total	67230.120	300	-	-	-
⊥20°	Layer thickness (A)	54.188	1	54.188	22962.129	0.000*
	Weathering period (B)	43.241	2	21.620	9161.729	0.000*
	Interaction (AB)	27.654	2	13.827	5859.278	0.000*
	Error	0.694	294	0.002	-	-
	Total	245.730	300	-	-	-
⊥60°	Layer thickness (A)	3934.941	1	3934.941	16685.839	0.000*
	Weathering period (B)	2195.554	2	1097.777	4655.046	0.000*
	Interaction (AB)	930.575	2	465.287	1973.019	0.000*
	Error	69.333	294	0.236	-	-
	Total	17520.370	300	-	-	-

⊥85°	Layer thickness (A)	10896.816	1	10896.816	27314.775	0.000*
	Weathering period (B)	1986.352	2	993.176	2489.569	0.000*
	Interaction (AB)	1188.538	2	594.269	1489.639	0.000*
	Error	117.287	294	0.399	-	-
	Total	32540.187	300	-	-	-
Adhe-sion	Layer thickness (A)	1.323	1	1.323	15.388	0.001*
	Weathering period (B)	11.976	2	5.988	69.648	0.000*
	Interaction (AB)	0.238	2	0.119	1.383	0.270**
	Error	2.063	24	0.086	-	-
	Total	116.433	30	-	-	-
Pen-dulum Hard-ness	Layer thickness (A)	7150.417	1	7150.417	132.112	0.000*
	Weathering period (B)	1368.633	2	684.317	12.643	0.000*
	Interaction (AB)	2834.433	2	1417.217	26.185	0.000*
	Error	2922.700	54	54.124	-	-
	Total	297595.000	60	-	-	-
DF: Degree of Freedom; * = Significant according to α ≤ 0.05; and ** = Insignificant						

Table 3 presents the homogeneity groups, averages, minimum and maximum values, coefficient of variation, and standard deviations for the lightness (*L**), yellow color (*b**) tone value, red color (*a**) tone value, surface adhesion strength, glossiness (parallel (//) and perpendicular (⊥) to the grain at 20°, 60°, and 85° angles), and pendulum hardness of the unaged (control) and aged doussie samples coated with 3 layers and 5 layers of UV system varnish.

According to the determined color parameter results, the *a** value increased, while the *L** and *b** values decreased for both the 3 coat and 5 coat applications at the end of a 504 h weathering period. The 3 coat and 5 coat UV system varnish specimens had average *L**, *a**, and *b** values of 48.0, 18.2, 24.3 and 50.3, 17.0, and 24.2, respectively, before weathering. The *b** value following the weathering period decreased from 24.3 to the range of 20.3 to 18.8 for samples with 3 coats, whereas for samples with 5 coats, it decreased from 24.2 to the range 13.8 to 9.3. The *a** tone values obtained at the end of the 252 h weathering period were higher than the control and those aged for 504 hours. The reason for the changes in color properties can be due to the occasional occurrence of an abundance of white or yellow solid deposits in wood in the pores (Kryn and Fobes 1959). Soğutlu and Sönmez (2006) reported that a decrease in *L** values may mean a darker color tone, and an increase in color may mean a lighter color tone.

The glossiness (perpendicular (⊥) and parallel (//) at 20°, 60°, and 85° angles) values of the experimental samples before weathering were higher in samples with 5 layers of UV system varnish in comparison to the samples with 3 layers of varnish. The glossiness values of the 5-coat application may have been higher than the values of the 3-coat application due to the fact that the wood was evenly distributed individually or in radial groups with two or three pores (Kryn and Fobes 1959). As the layer thickness increased, there was an increase in the glossiness value parallel to the fibers. This may be due to thick varnish layers completely filling the wood pores and changes in optical properties (Budakci 1997). For both varnish type applications, the gloss measurements parallel to the fibers were higher than the measurements perpendicular to the fibers. Similar results were obtained in 3 coat and 5 coat applications on lemonwood (Ayata 2019). The *UV and UV clear curing sealer chemicals used in a 5-coat application yielded high gloss results compared to UV curtain coating chemicals used in a 3-coat application. This result emphasizes the importance of the chemical composition of the varnish types.

According to the surface adhesion strength results shown in Table 3, the highest surface adhesion strength was obtained in samples with 3 coats and the control (2.910 MPa), and the lowest was obtained in samples with 5 coats (1.150 MPa), at the end of the 252 h weathering period. After the surface adhesion test, it was observed that the applied UV system varnish layers were completely separated from the wood material surface. It is understood from this that the expected adhesion gave the desired result. For single and double layer UV system parquet varnishes applied to sapeli (*Entandrophragma cylindricum*) and limba (*Terminalia superba*) wood (Ayata and Cavus 2018) according to industrial applications, it was said that the surface adhesion strength to the surface decreased as the number of layers increased. With the accelerated aging period from 204 h to 504 h, the adhesion resistance values decreased for both varnish applications (3 coats and 5 coats).

While the adhesion test decreased at the end of 252 h of aging for the 5-coat application, it increased slightly at the end of 504 h. In a thermal aging study on UV flooring, it was reported that after aging, the adhesion resistance increased in beech (*Fagus orientalis* L.) and Northern red oak (*Quercus rubra*), while in American black walnut (*Juglans nigra*) it decreased (Ayata *et al*. 2018). Bilgen (2010) reported that the temperature, humidity, different wavelengths of sunlight, and UV radiation will cause expansion in the varnish layer, thus reducing the adhesion between the varnish layer and the sample surface, which may lead to a decrease in adhesion resistance.

Before aging, the oscillatory hardness values were obtained for each sample, with the 5 coat samples having the highest hardness values (63.40), while the lowest values were reported in 3 coat UV system applications (60.80) (as shown in Table 3). It has been reported that the pendulum hardness value increases as the number of layers increase, in UV system varnishes applied to rowan (*Sorbus* L.), as reported by Gurleyen *et al*. (2017b), oak (*Quercus petraea* L.), as reported by Gurleyen *et al.* (2019), limba (*Terminalia superba*), chestnut (*Castanea sativa* Mill.), sapele (*Entandrphragma cylindrocum*), iroko (*Chlorophora excelsa*), as reported by Ayata and Cavus (2018), scotch pine (*Pinus sylvestris* L.), as reported by Gurleyen *et al*. (2017c), ash (*Fraxinus excelsior*) (heat-treated at 212 °C for 2 h), as reported by Ayata *et al*. (2017b), and beech (*Fagus orientalis* Lipsky.), as reported by Ayata *et al*. (2017a). The pendulum hardness results of the study were consistent with previous studies.

The hardness value varies from wood type to wood type (Sanivar and Zorlu 1980). While hard surfaces show more oscillation, surfaces with less hardness yield less oscillation (Sonmez 1989). In this study, it was seen that the UV system parquet varnish layers increased the surface hardness and thus the oscillatory hardness value when applied as 5 layers with long-term UV aging application, while the surface hardness decreased in 3 layer applications. The decrease in the hardness value was 3.4% for the 252 h and 11.4% for the 504 h weathering period for 3 coat samples, while the increase in the hardness value was 38.3% of 252 h for the 252 h weathering period and 38.5% for the 504 h weathering period for 5 coat samples, according to the pendulum hardness values (as shown in Table 3). It can be said that this was due to the structural properties of the different chemicals used in the 3 layer and 5 layer applications and the resin used in its production. It was reported by Clerc *et al*. (2017) that the loss of adhesion strength due to weather conditions is often due to wood deterioration rather than the chemical degradation of the adhesive.

Table 3. Statistical Data

Test	Layer Thickness	Weathering Period	N	*X*	*HG*	*SS*	Minimum	Maximum	COV
Lightness (*L**) value	3	Control	50	48.03	B	0.50	46.75	48.75	1.04
		252 hours	50	38.78	D	0.76	37.59	40.44	1.96
		504 hours	50	41.80	C	0.48	41.05	42.79	1.15
	5	Control	50	50.26	A*	0.81	46.95	51.88	1.61
		252 hours	50	35.22	E	0.25	34.92	35.83	0.71
		504 hours	50	33.18	F**	0.50	31.88	33.98	1.51
Red color (*a**) tone	3	Control	50	18.21	E	0.37	17.39	19.04	2.03
		252 hours	50	25.30	A*	0.63	23.88	26.10	2.49
		504 hours	50	20.36	D	0.32	19.67	21.14	1.57
	5	Control	50	16.95	F**	0.26	16.48	17.40	1.53
		252 hours	50	22.44	B	0.26	21.95	22.87	1.16
		504 hours	50	20.59	C	0.66	19.63	21.76	3.21
Yellow color (*b**) tone	3	Control	50	24.33	A*	0.30	23.74	25.04	1.23
		252 hours	50	20.26	B	0.17	20.03	20.75	0.84
		504 hours	50	18.80	C	0.37	18.05	19.39	1.97
	5	Control	50	24.24	A	0.44	23.33	25.14	1.82
		252 hours	50	13.79	D	0.29	13.17	14.68	2.10
		504 hours	50	9.27	E**	0.39	8.56	10.01	4.21
Glossiness at //20°	3	Control	50	0.36	C	0.14	0.30	0.70	38.89
		252 hours	50	0.30	D	0.00	0.30	0.30	0.00
		504 hours	50	0.10	E**	0.00	0.10	0.10	0.00
	5	Control	50	2.00	A*	0.07	1.80	2.10	3.50
		252 hours	50	0.82	B	0.08	0.60	0.90	9.76
		504 hours	50	0.33	D	0.08	0.30	0.60	24.24
Glossiness at //60°	3	Control	50	3.74	D	0.05	3.70	3.80	1.34
		252 hours	50	3.17	E	0.07	3.10	3.30	2.21
		504 hours	50	1.41	F**	0.15	1.30	1.70	10.64
	5	Control	50	17.82	A*	0.10	17.70	18.20	0.56
		252 hours	50	10.37	B	0.14	10.20	10.60	1.35
		504 hours	50	4.18	C	0.06	4.10	4.30	1.44
Glossiness at //85°	3	Control	50	6.95	D	0.22	6.50	7.30	3.17
		252 hours	50	6.65	E	0.15	6.50	6.90	2.26
		504 hours	50	2.00	F**	0.12	1.80	2.10	6.00
	5	Control	50	26.09	A*	0.49	25.50	27.40	1.88
		252 hours	50	21.48	B	0.99	18.70	22.20	4.61
		504 hours	50	10.25	C	0.37	9.50	10.80	3.61
Glossiness at ⊥20°	3	Control	50	0.30	C	0.00	0.30	0.30	0.00
		252 hours	50	0.21	D	0.03	0.20	0.30	14.29
		504 hours	50	0.11	E**	0.03	0.10	0.20	27.27
	5	Control	50	1.96	A*	0.08	1.80	2.00	4.08
		252 hours	50	0.90	B	0.08	0.80	1.00	8.89
		504 hours	50	0.31	C	0.03	0.30	0.40	9.68
Glossiness at ⊥60°	3	Control	50	3.37	D	0.16	3.10	3.60	4.75
		252 hours	50	2.35	E	0.19	2.10	2.80	8.09
		504 hours	50	1.06	F**	0.08	1.00	1.20	7.55
	5	Control	50	14.91	A*	1.11	12.60	15.60	7.44
		252 hours	50	9.63	B	0.32	9.20	10.30	3.32
		504 hours	50	3.98	C	0.05	3.90	4.10	1.26
Glossiness at ⊥85°	3	Control	50	1.79	E	0.26	1.30	2.30	14.53
		252 hours	50	2.89	D	1.06	2.20	4.50	36.68
		504 hours	50	0.71	F**	0.36	0.30	1.40	50.70

	5	Control	50	18.61	A*	0.90	16.50	19.30	4.84
		252 hours	50	15.14	B	0.31	14.50	15.70	2.05
		504 hours	50	7.79	C	0.39	7.20	8.50	5.01
Surface adhesion strength (MPa)	3	Control	5	2.910	A*	0.38	2.390	3.440	13.06
		252 hours	5	1.806	B	0.42	1.330	2.350	23.26
		504 hours	5	1.414	C	0.26	1.230	1.840	18.39
	5	Control	5	2.532	A	0.31	2.130	2.930	12.24
		252 hours	5	1.150	C**	0.09	1.060	1.290	7.83
		504 hours	5	1.188	C	0.16	1.030	1.420	13.47
Pendulum hardness	3	Control	10	60.80	BC	8.56	48.00	74.00	14.08
		252 hours	10	58.70	BC	6.33	51.00	68.00	10.78
		504 hours	10	53.90	C	7.22	43.00	64.00	13.40
	5	Control	10	63.40	B	7.76	54.00	74.00	12.24
		252 hours	10	87.70	A	6.20	78.00	98.00	7.07
		504 hours	10	87.80	A*	7.79	77.00	105.00	8.87
N: Measurements of Number; *X*: Average; *HG*: Homogeneity Group; *SD*: Standard Deviation; COV: Coefficient of Variation; * = Highest value; and ** = Lowest value									

The colour changes (Δ*L**, Δ*a**, Δ*b**, and Δ*E**) are presented in Table 4. As shown in Table 4, the total colour difference (Δ*E**) for the 3 coat wood samples was lower than the Δ*E** for the 5 coat wood samples. The total color difference decreased for samples with 3 coats and increased for samples with 5 coats at the end of the 504 h weathering period. In a study conducted by Payne (1965), it was reported that the total color change values were high in experimental samples with accelerated aging, which may have been caused by the free radicals formed as a result of photochemical reactions due to UV rays, sprinkling, and heat. Due to the high energy of ultraviolet wavelengths in sunlight, it causes deterioration in paint and varnish layers (Feist 1984).

Table 4. Total Colour Differences (Δ*L**, Δ*a**, Δ*b**, and Δ*E**)

Thickness Layer	Weathering Period	Δ*L**	Δ*a**	Δ*b**	Δ*E**
3	252 hours	-9.25	7.09	-4.07	12.34
	504 hours	-6.23	2.15	-5.53	8.60
5	252 hours	-15.04	5.49	-10.45	19.12
	504 hours	-17.08	3.64	-14.97	23.00

CONCLUSIONS

1. It can be said that the UV system varnish layer structure changes when subjected to accelerated aging, which included factors such as heat, temperature, water, *etc.*, according to the ISO standard 4892-3 (2016). Analysis of variance was performed for all tests. The aging process demonstrated the relationship between the UV system varnish application and all tests and how this relationship has changed. Regarding color, glossiness, and surface adhesion resistance values, these values decreased as the total time of the weathering period increased for doussie wood samples. The oscillatory hardness value showed an opposite result in 5 coat applications compared to 3 coat applications.

2. Different results were obtained with the application of varnishes with different chemical contents. As a result, if the pendulum hardness, color, glossiness, and surface adhesion resistance are important for doussie (*Afzelia africana*) wood when used with a UV system varnishes, 3 to 5 layers of varnish should be applied to the surface of the wooden material.

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