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Analysis of the wood properties of *Dicorynia guianensis* Amsh. in the context of using in outdoor architecture

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Abstract: *Analysis of the wood properties of Dicorynia guianensis Amsh. in the context of using in outdoor architecture.* This article deals with the analysis angélique wood (*Dicorynia guianensis* Amsh.) properties to verify suitability for use in the arrangement of external architecture such as the construction of terraces. Particularly, tests included determination of hardness by the Brinell method and total and partial shrinkage. The presented characteristic of properties was complemented by the analysis of wood colour stability during exposition to natural weathering factors for six months. Changes of particular colour parameters (lightness L*, chroma C*, hue h) were determine as well as the total colour change ΔE*. The colour stability was examined on untreated wood surface as well as on wood finished with clear and colouring oils. It was found that the angélique wood belongs to the group of very heavy wood (specific gravity 807 kg/m^3) and is characterized by the favourable technical parameters, primarily the high hardness (average hardness 45,64 MPa). Furthermore, the angélique wood is the wood of average shrinkage (average total shrinkage 14,37%). Dimensional stability does not differ from the properties of wood commonly and successfully used for wooden external construction. The results showed that during external exposition angélique wood became darker. Using wood surface protection preparations such as oils resulted in the slowing down the weathering processes effects.

Keywords: *Dicorynia guianensis* Amsh., angélique, Guayana teak, bangkirai, yellow balau, Brinell hardness, CIELab, colour change, total and partial shrinkage, wood aging, wood weathering

INTRODUCTION

Tropical wood is a popular material in Europe for the production of terrace boards, mainly due to its usually high durability and aesthetic aspects. The commercial offer of wood available on the market is being updated. One of the new types of wood is angélique - wood from evergreen trees of *Dicorynia guianensis* Amsh. species. *Dicorynia guianensis* Amsh. depending on the place of occurrence, has various names given by the natives, the names basralokus and barakaroeballi come from Suriname, the names angelique and teck de guyane can be heard in French Guiana (Chchignoud et al. 1990). The most common brand name is Guyana teak, which is due to the visual similarity to teak wood and it is one of the most exploited wood in French Guiana (Vanbellingen et al. 2016).

Dicorynia guianensis Amsh. genus is found in the largest continuous area of lowland tropical rainforests in the world, located in eastern Suriname and western French Guiana, where it can account for 10% of the stand (Paradis et al. 2011). It grows best in deep, loamy, well-drained soils of lowland plains, but is also found in wetlands (Chudnoff 1984). Under native conditions, it takes the form of a tall tree. The average height measured from the buttress to the first branches is about 29 m, and the average trunk diameter is approximately 60 cm. The maximum dimensions are 46 m in height and a diameter of 152 cm, measured above the low buttresses (Kukachka 1964).

Interest in angélique wood results from its technical characteristics (especially for its durable heartwood) and attractive appearance. The colour of heartwood varies from tree to tree, producers recognize two forms. The first is referred to as "gris" - the freshly cut heartwood is rusty in colour, which becomes dull on the surface, brown with a purple tinge.

The second form is "angel pink", it is more reddish with wide purple stripes present. Angélique wood can have different fibres arrangement (grain patterns) - from straight to wavy (Wiemann 2010).

Working properties vary depending on the density and fine silica deposit content. The wood has a smooth finish, especially when using cutters with a special tip for dried wood. Gluing does not cause any problems (Chudnoff 1984). The specific gravity of angélique at 12% is 790 kg/m^3 (Simpson and Sagoe 1991). Strength properties enable versatile use. Earlier use of angélique wood was particularly limited to heavy loaded construction - harbour installations, bridges, heavy planking for pier and platform decking, and railroad bridge ties (Kukachka 1964). Today, angélique is used in other areas, such as exterior construction - gates, windows, doors, terraces, facades, and in interior design - stairs and parquet floors (Internet 1). Wide application possibilities are result of technical characteristic of wood. The species also exhibits an unusually high level of variability in contact with fungi. According to standard PN-EN 350:2016-10, classification of the natural durability of heartwood to wood-destroying fungi and termites are sequentially 2v and M - durable and moderately durable. Sapwood width is small, about from 2 to 5 cm. Treatability of heartwood and sapwood are sequentially 4 and 2 - extremely difficult to treat and moderately easy to treat.

The need to conduct research on angélique wood resulted from the fact, that this species is a novelty on the Polish and European market and the desire to test its functional properties in the Central European lowland. Angélique appeared on the European market only over a dozen years, while it has only been on the Polish market for 2-3 years, so it is a relatively new species and rarely used. There are also few scientific reports on the properties of this wood. The offer of decking boards is extremely wide and constantly supplemented. Species frequently used in exterior architecture, such as kempas, yellow balau or cumaru, have been already well known by customers and installers, while less common grades need to be supplemented with appropriate research. From that point of view, the important issue is determining appearance changes od wood surfaces when is exposed in outside. The knowledge in this area allows predicting those changes as well as lets to compare among different wood species. It is always recommended to protect wood surface during outside exposition due to weathering, especially in the context of making wood colour more stable and acting hydrophobically (Hill et al. 2022; Oberhofnerová et al. 2017). But most of the previous experiences focused on not finished wood (Vidholdová et al. 2018; Jirouš-Rajković 2004; Geffertová et al. 2018).

The aim of the study was to determine selected physical and mechanical properties of angélique (*Dicorynia guianensis* Amsh.) wood that are important from technological point of view resulting of usage in exterior construction such as terraces. The scope of conducted research included colour change determination during external exposition in various variants of wood surface protection, total and partial shrinkage and hardness. The collected results were compared with another popular wood used in outdoor architecture such as yellow balau (*Shorea laevis* Ridley.) that has been present on European market at least for 14 years so now.

MATERIAL AND METHODS

Material preparation

The research material angélique (*Dicorynia guianensis* Amsh.) wood were provided by DLH Global S.A. company in the form of grooved decking boards. As comparison in colour testing, yellow balau (*Shorea laevis* Ridley.) wood was used in the same form as angélique wood. The products were imported - angélique from Suriname and yellow balau from Indonesia (Java Island).

The decking boards came from the same batch, the samples were made of four boards. The defect-free (knots and cracks free) materials were selected. The presence of dangerous species of fungi for exotic trees was not noted, therefore the tested samples should not have any changes in the composition of the wood and it should not be weakened (fig. 1). Boards were planned, sanded and after, the appropriate samples were made.

Figure 1. Example of decking boards used for the colour change tests.

The first group of samples were intended for the wood surface colour change determination. The test includes wood weathering in natural exterior conditions of three group of samples:

1. non finished wood,
2. wood finished with clear oil - WOCA Exterior Water Oil,
3. wood finished with pigmented (colouring) oil - WOCA Exterior Water Oil in TEAK colour.

The samples size was 20x135x500 mm.
The rest of the material was intended for testing shrinkage and hardness. The size of the samples complied with the recommendations of the relevant standards.

Wood weathering

As a part of the research a natural weathering of tested wood species was performed to determine colour changes of wood surfaces during exterior exposition in natural environment. The natural weathering of samples was performed from the end of February to the beginning of September 2021 on eighteen samples, six of them were from the yellow balau, the remaining twelve belonged to angélique. The samples were exposed to external conditions in Warsaw six months, under a slope of 45° (fig. 2). The samples were exposed to the south. Tests were carried out according to the standard PN-EN 927-3:2020-01. The period of exposition was divided for two three months parts and between periods, wood properties were determined. In the table 1 the weather conditions during the exposure of the samples were presented, the data were from the Institute of Meteorology and Water Management - National Research Institute (Internet 2).

Table 1. Weather conditions during natural outdoor exposure for 1–6 months (selected from measurements by Institute of Meteorology and Water Management - National Research Institute).

Weather conditions	Weathering time	
	15.02-25.05.2021	**25.05-9.09.2021**
Average temperature (°C)	4,6	17,7
Sum of precipitation (mm)	35 - 45	95 - 110
Average monthly actual solar irradiation (h)	150 - 160	230 - 240

Figure 2. Samples exposed to weather conditions, February 2021.

Colour changes measurements

After each period of weathering, the samples were assessed for the change in L*a*b colour space, appropriate calculations were made (CIE 2004):

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad (1)$$

where ΔE^* - the difference between two colours in the CIELab space (total colour change), L^* - brightness (lightness), a^* - colour from green to magenta, b^* - colour from blue to yellow;

$$C^* = \sqrt{(a^*)^2 + (b^*)^2} \quad (2)$$

$$\Delta C^* = C_1^* - C_2^* \quad (3)$$

where C^* - chroma;

$$\Delta H^* = \sqrt{(\Delta E^*)^2 - (\Delta L^*)^2 - (\Delta C^*)^2} \quad (4)$$

where ΔH* - hue difference.

The results were interpreted in accordance with the accepted standards for measuring color changes (Mokrzycki and Tatol 2011).

The mean values of tested individual colour parameters L*, a* and b* were compared using a one-way analysis of variance (ANOVA) and Tukey's post hoc test, in which homogeneous groups of mean values for each parameter were identified for $p = 0.05$. The significance of the influence on the considered variables was calculated using a multi-factor ANOVA test by the determination of percentage contribution for the analysed factors. The experimental data were statistically analysed using the STATISTICA 13.3 software (TIBCO Software Inc., Palo Alto, CA, USA).

Shrinkage determination

The scope of the research included total and partial shrinkage. Partial shrinkage was determined at a moisture content between 18% and 30%. The samples were measured in the tangential, radial and longitudinal directions, and their mass was also determined. The measurements were collected in three cases - at moisture content level of 18%, after soaking and after drying in the dryer. The tests were performed on forty-one samples with dimensions 25x25x10 mm (fig. 3), based on the PN-D-04111:1982 standard. The total and partial shrinkage was calculated according to the following formula (PN-D-04111:1982 and Kozakiewicz 2006):

$$k_O = \frac{a_y - a_x}{a_O} \tag{5}$$

$$K_O = \frac{a_{pwn} - a_O}{a_O} \tag{6}$$

where: k_O - partial shrinkage [%], K_O - total shrinkage [%], a_x, a_y - dimensions with appropriate wood moisture content, a_O - dimension of the wood in absolutely dry condition, a_{pnw} - dimension of wood in moist state.

Wood hardness determination

As a part of the research Brinell hardness test was determined. The measurements were performed for 25 seconds, with the load of 1000 N. On a sample with dimensions of 50x50x25 mm (fig. 3), four measurements were made. As the measurement of wood shrinkage, the tests were also made only on angélique wood. The tests were based on the standard PN-EN 1534:2020-06 and the formula:

$$HB = \frac{2F}{\pi D(D - \sqrt{D^2 - d^2})} \tag{7}$$

where: HB - Brinell hardness [N/mm^2], F - loading force [N], D - ball diameter [mm], d - imprint diameter [mm].

Figure 3. Samples used for the total and partial shrinkage test and for the Brinell hardness test.

During total and partial shrinkage tests, wood moisture and density were also determined in accordance with PN-EN 13183-1:2004 and PN-D-04101:1977. All data from particular test was compiled - means, minimums, maximums and standard deviation were calculated.

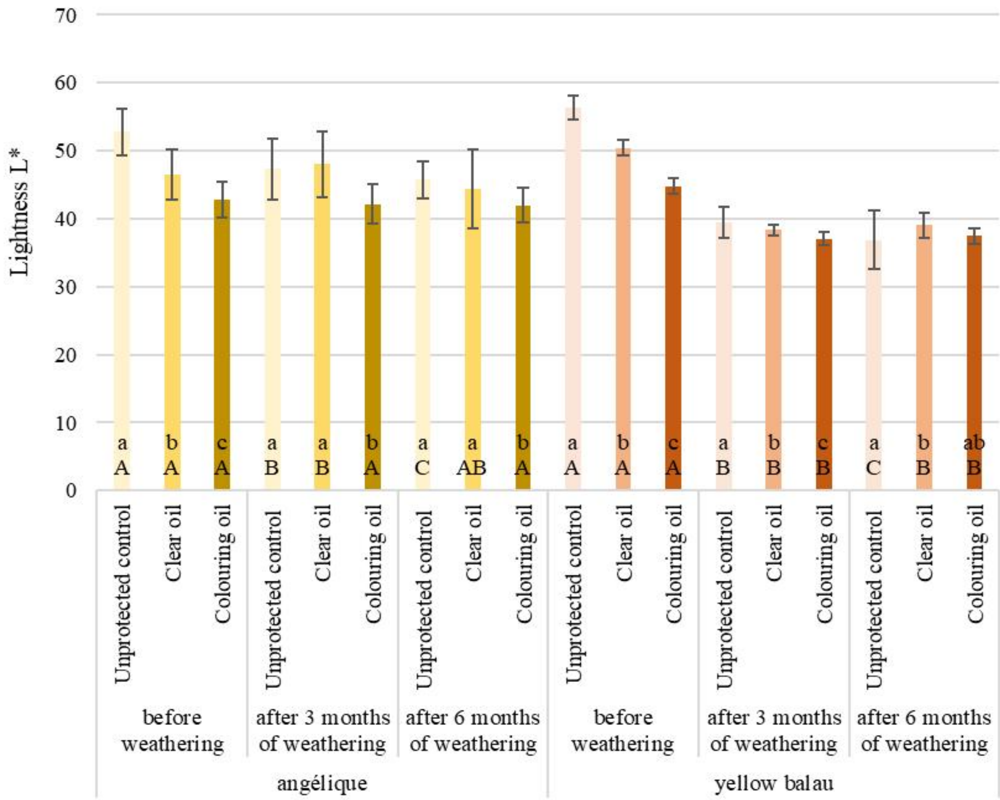
RESULTS AND DISCUSSION

Colour changes

The results of colour measurement of tested species wood surfaces before and during natural weathering are given in figure 4, 5 and 6. The charts presents the average results of the individual colour parameters L*, a* and b*, broken down by species and taking into account the test period and the method of oiling the wood surfaces.

The oiled samples of angélique and yellow balau wood before weathering, at the beginning showed less lightness than the unprotected ones. Covering the surface of yellow balau and angélique wood with oils before weathering statistically significantly influences the lightness. During weathering it was observed that the angélique wood samples showed smaller scope of changes than yellow balau wood. In both cases, the use of the colouring oil reduced the colour changes of the wood during the weathering process. Angélique unprotected samples darkened, while samples from clear oil brightened after 3 months, after another period the wood started to darken. The indicators of yellow balau wood in the unprotected group showed a tendency to darken, in the clear oil and colouring oil groups, the wood was lightened after darkening in the first phase of the test. Statistically significant differences in lightness occurred for angélique wood after 6 months of weathering.

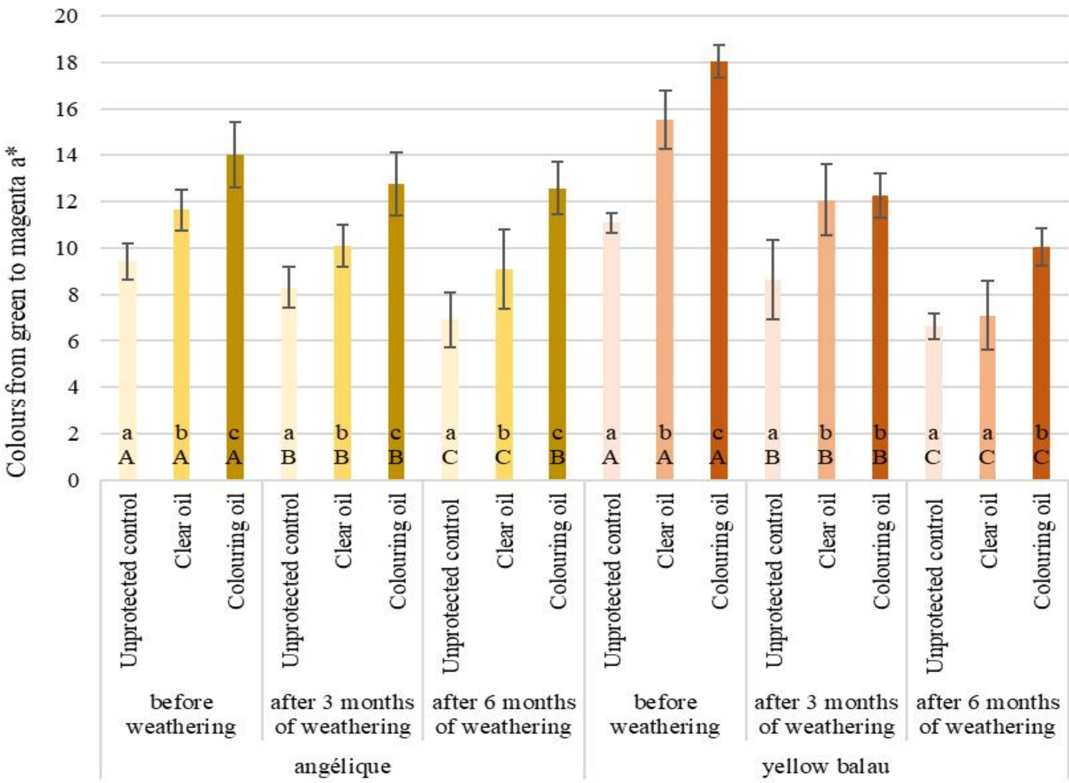
Parameter a* shows the relation between the colours from green to magenta in the analysed object, where the shades of green have a negative value, and the shades of magenta - a positive value. For angélique and yellow balau wood, the indicators in each variant decreased over the time. The wood was greenish, however the changes on the angélique wood were more even and less abrupt (in each variant). Oily samples of angélique and yellow balau wood before weathering, at the beginning show a greater parameter of magenta colour than the unprotected ones. Covering angélique wood with oils is statistically significant throughout the weathering process. Weathering time has a statistically significant effect on both species.



The a, b, c - indicate whether the oil coating influenced the colour parameters (a separate analysis was performed for each time).
The A, B, C - indicate whether time affects the colour parameters (a separate analysis was performed for each coverage)

Parameter b* shows the relation between the colours from blue to yellow in the analysed object, where the shades of blue have a negative value, and the shades of yellow - a positive value. In the parameter b*, as well as in the parameter a*, it was possible to notice declines in indices in each variant of each species. The wood colour was turning bluer, however, the changes to the angélique wood were more even and less abrupt (in each variant). Oiled samples of angélique and yellow balau wood before weathering, initially showed a higher parameter of yellow colour than the unprotected ones. In yellow balau oil coverage has a statistically significant effect on the parameter b*. No statistically significant differences were observed for the parameter b* in angélique before weathering and after 3 months.

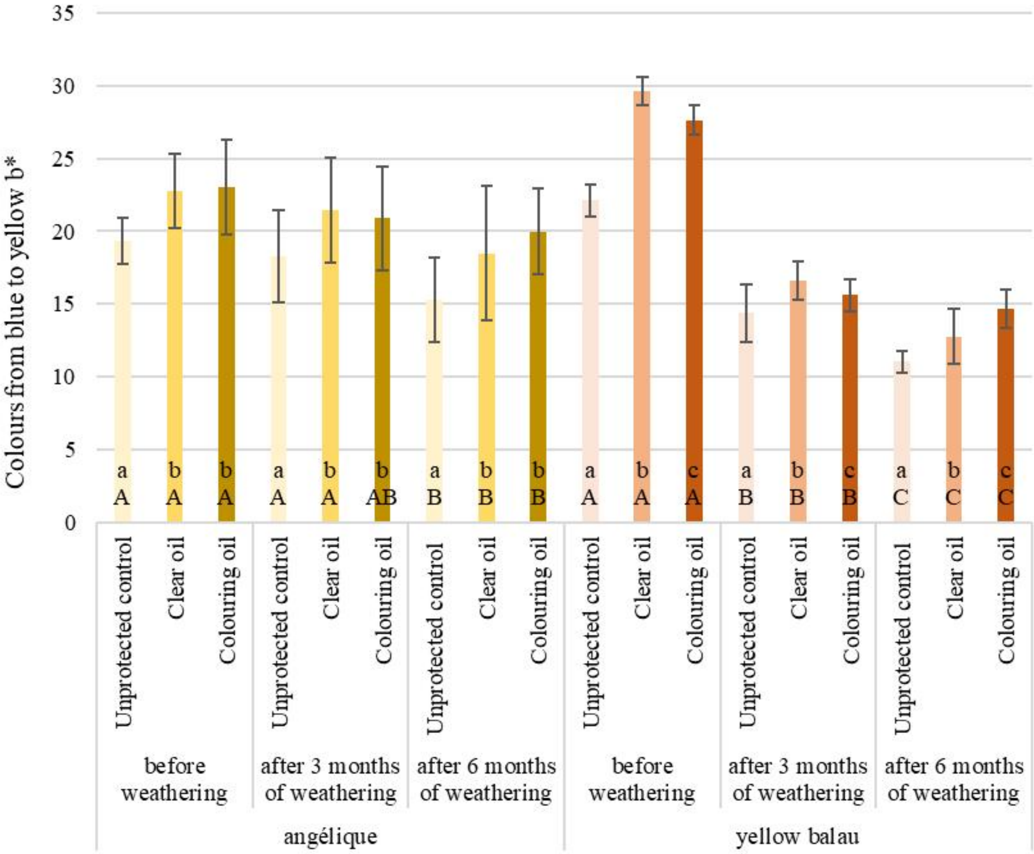
Figure 4. L* parameter change assessed according to the CIELab colour system (means and standard deviation, a, b, c, A, B, C. Homogeneous groups were determined by the Tukey test; different letters denote a significant difference; means followed by the same letter do not statistically differ from each other).



The a, b, c - indicate whether the oil coating influenced the colour parameters (a separate analysis was performed for each time).
The A, B, C - indicate whether time affects the colour parameters (a separate analysis was performed for each coverage).

Although the dynamics of changes for both species can be considered similar, in case of angélique wood smaller changes were observed, and in particular wood oiled with colouring oil. After oiling, the samples revealed slight differences between the measurements over time.

Figure 5. a* parameter change assessed according to the CIELab colour system (means and standard deviation, a, b, c, A, B, C. Homogeneous groups were determined by the Tukey test; different letters denote a significant difference; means followed by the same letter do not statistically differ from each other).



The a, b, c - indicate whether the oil coating influenced the colour parameters (a separate analysis was performed for each time).
The A, B, C - indicate whether time affects the colour parameters (a separate analysis was performed for each coverage).

Figure 6. b* parameter change assessed according to the CIELAB colour system (means and standard deviation, a, b, c, A, B, C. Homogeneous groups were determined by the Tukey test; different letters denote a significant difference; means followed by the same letter do not statistically differ from each other).

Except for a colour change, the weathering process caused small cracking (microcracks) of the wood samples and the surface of the samples became rougher especially in case not finished wood. Oiled wood proved to be more resistant to changes caused by external factors. Environmental factors mainly degrade the chemical components found in wood, such as lignin, cellulose and hemicelluloses (Turkoglu et al. 2015). Ultraviolet light has a significant influence on chemical changes in the structure. Lignin constitutes 20-30% of the wood tissue and due to its phenolic nature, lignin absorbs most of the UV radiation, which in turn causes its degradation (Jankowska et al. 2014). Photon energy in sunlight (ultraviolet, visible and infrared) is extremely harmful, initiating various chemical changes on the wood surface (Baysal et al. 2014). The application of clear varnish is the most common method of protecting the wood against natural weather conditions. The thickness of its coating decreases with the increase of aging time, and during aging the tissue under the coating surface deforms (Saha et al. 2011).

Table 2. The results of the colour deviation from the standard (ΔE), chroma (ΔC) and hue difference (ΔH) in angélique wood.

angélique	After 3 months*	After 6 months*
Group of unprotected samples	**ΔE = 5,96** 5 <ΔE - the observer has the impression of two different colours	**ΔE = 9,04** 5 <ΔE - the observer has the impression of two different colours
	ΔC <0	ΔC <0
	ΔH = 0,52	ΔH = 0,57
Group of clear oil samples	**ΔE = 3,35** 2 <ΔE <3,5 - the inexperienced observer notices the difference	**ΔE = 6,23** 5 <ΔE - the observer has the impression of two different colours
	ΔC <0	ΔC <0
	ΔH = 0,91	ΔH = 0,53
Group of colouring oil samples	**ΔE = 2,70** 2 <ΔE <3,5 - the inexperienced observer notices the difference	**ΔE = 3,72** 3,5 <ΔE <5 - the observer notices a clear difference in colours
	ΔC <0	ΔC <0
	ΔH = 0,38	ΔH = 0,45

*The results were interpreted in accordance with the accepted standards for measuring color changes (Mokrzycki and Tatol 2011).

Table 3. The results of the colour deviation from the standard (ΔE), chroma (ΔC) and hue difference (ΔH) in yellow balau wood.

yellow balau	After 3 months*	After 6 months*
Group of unprotected samples	**ΔE = 18,93** 5 <ΔE - the observer has the impression of two different colours	**ΔE = 22,90** 5 <ΔE - the observer has the impression of two different colours
	ΔC <0	ΔC <0
	ΔH = 1,46	ΔH = 1,36
Group of clear oil samples	**ΔE = 18,12** 5 <ΔE - the observer has the impression of two different colours	**ΔE = 22,03** 5 <ΔE - the observer has the impression of two different colours
	ΔC <0	ΔC <0
	ΔH = 3,78	ΔH = 0,41
Group of colouring oil samples	**ΔE = 15,41** 5 <ΔE - the observer has the impression of two different colours	**ΔE = 16,91** 5 <ΔE - the observer has the impression of two different colours
	ΔC <0	ΔC <0
	ΔH = 2,24	ΔH = 0,61

*The results were interpreted in accordance with the accepted standards for measuring colour changes (Mokrzycki and Tatol 2011).

Impregnation with wood preservatives followed by the application of permanent coatings or varnish/paint makes the wood more resistant to photochemical degradation, dimensional changes and biological organisms and increases the service life of the impregnated wood (Turkoglu et al. 2015), which has been shown in the tests. With the passage of time, the indices of wood colour measures showed less of a tendency to change, which may be caused by the existence microcracks and migration of extractive substances on the wood surface (Liu et al. 2019).

The second group of results includes the total colour change (ΔE), chroma change (ΔC) and hue (ΔH) difference during the weathering. The results are presented in Tables 2 and 3. In each species, the samples were compared in three groups - raw wood and oiled with both variants of the oil (clear and colouring).

For angélique wood, the total colour change (ΔE) was much smaller, within the range of 2,70-9,04. The smallest changes over time were shown by samples protected with colouring oil. Each group also showed lesser colour saturation during weathering. In the group of unprotected samples and in the group finished with colouring oil, an increase in the hue angle was observed, in contrast to the clear oil samples. Yellow balau wood was characterized by greatest scope of the total colour change (ΔE), in the range of 15,4-22,90. The smallest changes over time were shown by samples coated with colouring oil. Each group showed less colour saturation during weathering. Also, the hue angle of the sample decreased compared to the unfinished wood surfaces, the greatest change was observed in the samples protected with both variants of the oil.

The available literature data concerning the research on the colour changing of tropical wood were mainly performed on species other than angélique and they were performed in the raw state, i.e. without the use of impregnation. The conducted tests do not differ from the trends obtained on other exotic species (Reinprecht et al. 2018). Tropical wood darkens, turns grey with a long time of external exposition and shows a greater difference in colour as seen by an observer. However, the conducted research confirmed that appropriate impregnation of external wood let obtaining results in the form of slowing down the aging processes. In particular, the oil with a pronounced pigment was more active. The differences between angélique and yellow balau may have resulted from the unique features of each species and its predisposition, place of origin and individual differences on the level of chemical structure, which requires further analysis as is know the influence of wood extractives on the photo-discoloration of wood surfaces exposed to artificial weathering (Nzokou and Kamdem 2006).

Shrinkage

Shrinkage green to ovendry *Dicorynia guianensis* Amsh. wood, according to literature data should be - radial 5,2%, tangential 8,8% and volumetric 14,0% (Internet 3). Compared to angélique wood, the values of yellow balau in the radial and tangential directions are at the same level, the volumetric contraction is almost identical with values obtained in presented study - radial 4,2%, tangential 9,5% and volumetric 14,0% (Jankowska 2012). The results of dimensional stability of angélique wood are presented in Table 4 and 5. Based on the results it can be said that angélique wood is a medium-shrinkable with average anisotropy of shrinkage in the tangential and radial directions. The variability of linear shrinkage (tangential, radial) can be influenced by fibres arrangement (Jankowska 2018).

Table 4. Total shrinkage of *Dicorynia guianensis* Amsh. wood (shrinkage green to ovendry) test results (%).

	Tangential	**Radial**	**Volumetric**
Minimum	7,90	3,71	13,42
Average	**8,86**	**5,40**	**14,37**
Maximum	10,78	6,31	15,57
Standard deviation	0,01	0,01	0,01

Table 5. Partial shrinkage of *Dicorynia guianensis* Amsh. wood (shrinkage from green to 18% moisture content) test results (%).

	Tangential	**Radial**	**Volumetric**
Minimum	5,22	1,68	7,38
Average	**6,98**	**3,59**	**11,65**
Maximum	8,35	4,97	13,43
Standard deviation	0,01	0,01	0,01

Brinell Hardness

The average values of Brinell hardness, distinguishing the lowest and the highest measurements results, are shown in Table 6. The results determine the hardness of the wood tested perpendicular to the grain at the moisture content 15% (moisture content for wood used outdoors). Determined density of tested wood samples was from 801 to 813 kg/m^3 (average 807 kg/m^3). Average Brinell hardness of tested *Dicorynia guianensis* Amsh. wood was 45,64 MPa.

Table 6. Brinell hardness test results (MPa).

Minimum	Average	Maximum	Standard deviation
33,05	**45,64**	**60,94**	0,54

Literature data include the wood of *Dicorynia guianensis* Amsh. as hard wood species (Kukachka 1964; Gérard et al. 2017), but there are no reliable specific data on the hardness of wood in the literature. The Brinell hardness of yellow balau wood with a moisture content of 12%, when tested across the grain is 31-47 MPa (Jankowska 2012), compared to angélique wood, these values are comparable. On this basis, it should be assumed that the wood is suitable for use as floor elements (both indoors and outdoors).

CONCLUSIONS

Based on the study of angélique (*Dicorynia guianensis* Amsh.) and yellow balau (*Shorea laevis* Ridl.) wood, the following conclusions were made:

1. The weathering of tropical wood, naturally outside under a 45 ° slope, caused the formation of longitudinal microcracks, darkening, greening and bluing, losing colour saturation.
2. During natural weathering, angélique wood showed small colour changes when compare with yellow balau wood. Oiling wood surfaces slowing down colour changes.
3. In each type of wood oiling (clear oil, colouring oil), a significant slowing down of the weathering processes effects was observed that allow assumption that it extends the life cycle of the wood.
4. Angélique wood is a medium-shrinkable (average total shrinkage 14,37%) with average anisotropy of shrinkage in the tangential and radial directions. Dimensional stability does not differ from the properties of wood commonly and successfully used for wooden external construction.
5. Recorded values of Brinell hardness (average 45,64 MPa) is at the same level as in case of wood species of similar density.

In summary, angélique wood showed relatively high colour stability during outdoor exposure. On the basis of the obtained results (dimensional stability, hardness), and with high natural durability, angélique is a wood predisposed for use in external constructions.

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Streszczenie: *Analiza właściwości drewna Dicorynia guianensis Amsh. w kontekście jego wykorzystania w architekturze zewnętrznej.* W ramach pracy dokonano analizy właściwości drewna angélique (*Dicorynia guianensis* Amsh.) w celu weryfikacji przydatności do zastosowania w aranżacji architektury zewnętrznej, takiej jak budowa tarasów. Zakresem badań objęto określenie twardości metodą Brinella oraz skurczu całkowitego i częściowego drewna. Przedstawiona charakterystyka właściwości została uzupełniona o analizę stabilności barwy drewna w czasie jego półrocznej ekspozycji na naturalne czynniki atmosferyczne. Określono zmiany poszczególnych parametrów barwy (jasność L*, nasycenie C*, odcień h) oraz całkowitą zmianę barwy ΔE*. Stabilność koloru badano na powierzchni drewna niczym niezabezpieczonego, a także na drewnie pokrytym olejem bezbarwnym i barwiącym. Stwierdzono, że drewno angélique należy do grupy drewna bardzo ciężkiego (gęstość średnia 807 kg/m^3) i charakteryzuje się korzystnymi parametrami technicznymi, przede wszystkim wysoką twardością (średnia twardość 45,64 MPa). Ponadto drewno angélique jest średniokurczliwym (średni skurcz całkowity 14,37%). Stabilność wymiarowa nie odbiega od właściwości drewna powszechnie i z powodzeniem stosowanego w drewnianych konstrukcjach zewnętrznych. Wyniki pokazały, że podczas ekspozycji zewnętrznej drewno angélique ciemniało. Stosowanie preparatów do ochrony powierzchni

drewna takich jak oleje spowodowało spowolnienie efektów procesu starzenia, spowodowane czynnikami zewnętrznymi.

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