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Chromated copper arsenate treatment on paricá wood

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ABSTRACT: This study investigated the influence of a commercial treatment used for *Eucalyptus* sp. fenceposts with chromated copper arsenate (CCA) on paricá (*Schizolobium parahyba* var. *amazonicum*) round wood. Treated and untreated samples were taken from the sapwood area to perform anatomical analysis, physical and mechanical characterizations and biological resistance in the field tests for 6 months. 95% confidence t-Student tests were performed to evaluate any statistical differences between the properties of the treated and untreated samples. The minimum CCA retention level was 8.18 kg.m^{-3}, and no detectable changes in wood anatomy and physical and mechanical properties were found. Despite the improvement in the biological resistance of paricá wood, the remaining mass loss in the treated samples can be attributed to inhomogeneous CCA distribution, caused by the presence of tyloses and extractive substances.
Key words: *Schizolobium* sp., preservation, CCA, anatomy, biodegradation.

Efeitos do tratamento com arseniato de cobre cromatado na madeira de paricá

RESUMO: O objetivo deste trabalho foi investigar a influência do tratamento comercial utilizado em mourões de *Eucalyptus* sp. com arseniato de cobre cromatado (CCA) na madeira roliça de paricá (*Schizolobium parahyba* var. *amazonicum*). Amostras tratadas e não tratadas provenientes da região do alburno foram utilizadas nas caracterizações anatômica, física e mecânica e avaliação da resistência biológica em campo durante seis meses. Testes t-Student com 95% de confiança foram realizados para avaliar diferenças estatísticas entre as propriedades das amostras. A retenção mínima de CCA foi de 8,18 kg.m^{-3}, não tendo sido detectadas modificações na estrutura anatômica e nas propriedades físicas e mecânicas. Apesar da melhoria da resistência biológica da madeira de paricá, a perda de massa residual poderá ter sido ser atribuída à heterogeneidade da distribuição do CCA, causada pela presença de tiloses e extrativos.
Palavras-chave: *Schizolobium* sp., preservação, CCA, anatomia, biodegradação.

INTRODUCTION

Wood is susceptible to degradation by both biotic and abiotic agents which demand careful consideration during the design and construction stages, once timber degradation attributed to fungal decay and termite damage typically occurs in temperatures above 20 ºC (CARVALHO et al., 2019). Paricá (*Schizolobium parahyba* var. *amazonicum*) is susceptible to attacks by xylophagous, demanding preservative treatments (TEREZO et al., 2017) to enhance its suitability for long-use applications such as fenceposts. This is an Amazonian species and can be found in forestry areas (ELOY et al., 2023) serving as raw material suppliers for the plywood industry located in the Northeast region of the state of Pará (LIMA et al., 2022).

The chromated copper arsenate (CCA) pressure treatment method is mostly used in building construction as sawn and round timber in structural or non-structural applications due to its effectiveness against fungi, insects, and marine borers (ARANTES et

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al., 2017). TEREZO et al. (2017) conducted a study on the biological resistance of CCA pressure-treated paricá sawn wood against insect attack. The authors found a *Cryptotermes brevis* (Walker) mortality of 75.6% in treated samples and around 33% in untreated samples. Limited information about the effects of CCA pressure treatment in paricá round timber is available. This study investigated the influence of a commercial treatment used for *Eucalyptus* sp. fenceposts CCA on paricá (*Schizolobium parahyba* var. *amazonicum*) round wood.

MATERIALS AND METHODS

Samples measuring 30 cm in diameter and length were cut at approximately 1.30 m above ground level from twelve 5 years-old paricá logs. This wood treatment process is the only commercially available in the Maranhão State. Following LOPES et al. (2017), six samples underwent a commercial *Eucalyptus* sp. fencepost CCA pressure treatment, consisting of a 1,0 MPa full-cell process for 200 minutes. For the CCA homogeneity and retention tests, chromazurol reagent was applied in six sapwood-treated samples measuring (50 x 50 x 150) mm³ and wood dust was obtained from each one. Therefore, an X-ray fluorescence analyser (Oxford Lab-X 2500 Wood Analysis) was used to obtain the CCA retention level in kilograms per cubic meter of wood.

For the anatomic study, six treated and untreated sapwood specimens measuring (15 x 15 x 15) mm³ were softened in a glycerine-distilled water solution (12,5% and 37,5%, respectively), and then maintained in a kiln under 60 ºC temperature. The specimen was sectioned by hand-blading in the transverse, tangential, and radial planes. Histology slide preparation consisted of transverse, tangential, and radial planes hand-bladed samples clarified in 60% sodium hypochlorite, stained with 1% safranin, and mounted in 50% glycerin. For the vessel's measurement, anatomical sections were clarified using sodium hypochlorite neutralized with 1% acetic acid, stained with 1% safranin and mounted 50% glycerine, and then analyzed using Image J software, resulting in 171 diameters and 25 length determinations. For fibre mensuration, NBR 15066 (ABNT, 2004) standard was followed to proceed to wood chips maceration, followed by sealing in a kiln under 60 ºC for 48 hours. After removing the distilled water solution, wood chips were stained with 1% safranin.

Bulk density and moisture content determination according to NBR 7190-3 (ABNT, 2022) standard was conducted in six treated and six untreated sapwood specimens with dimensions of (20 x 30 x 50) mm³. The compressive strength and modulus of elasticity parallel to the grain (f_{c0} and E_{c0}, respectively) tests following NBR 7190-3 (ABNT, 2022) standard were conducted in six treated and six untreated sapwood specimens with dimensions of (50 x 50 x 150) mm³ in a universal testing machine INSTRON EMIC 23-100 (10 MPa.min^{-1} load rate).

The field biological resistance test was conducted in an open-air and clear from vegetation area (4°56'37.6"S 47°28'42.6"W). 36 treated (T series) and 36 untreated (NT series) specimens measuring (50 x 50 x 300) mm³ were half-length buried and exposed to rain and sun radiation for 6 months. The exposition period started in February/2023 and ended in August/2023, which included one rainy season during the first 4 months. For the mass loss determination for each month, six treated and six untreated specimens were removed from the soil, and dried in a kiln (103 ± 2 ºC) until anhydrous mass was reached. Mass loss was equal to the difference between initial and final anhydrous masses. t-Student tests with 95% confidence were carried out to assess any statistical differences between the anatomical characteristics, physical and mechanical properties as well as mass loss of the treated and untreated samples.

RESULTS AND DISCUSSION

CCA retention values varied from 8.18 kg.m^{-3} to 21.13 kg.m^{-3}, with an average value of 13.05 kg.m^{-3} (standard deviation of 4.56 kg.m^{-3}). All specimens exhibited irregular total penetration. The minimum CCA retention value obtained meets the minimum value (6.5 kg.m^{-3}) of the NBR 16143 (ABNT, 2013) standard for use category 5 for general cases for pressure-treated round and sawn timber. As shown in figure 1, the paricá sample showed paratracheal vasicentric to lozenge aliform axial parenchyma with diffuse pores. Vessels were arranged diagonally, mostly solitary, rarely twinned, and occasionally in radial multiples. The tangential section showed multiseriate parenchyma with 3-cell-wide and 20-cell-long structures. In the radial section, only elongated vessel cells were visible. Intravessel pits and perforation plates were simple, while fibres were libriform with simple bordered pits and fibrotracheids.

As shown in table 1, the average vessel diameter was measured at 246.744 µm, categorizing them as "big" according to the International Association of Wood Anatomists Committee - IAWA (1989). The average vessel width was 34.32 µm, with 3-4 cells, and the average vessel height of 229.35 µm,

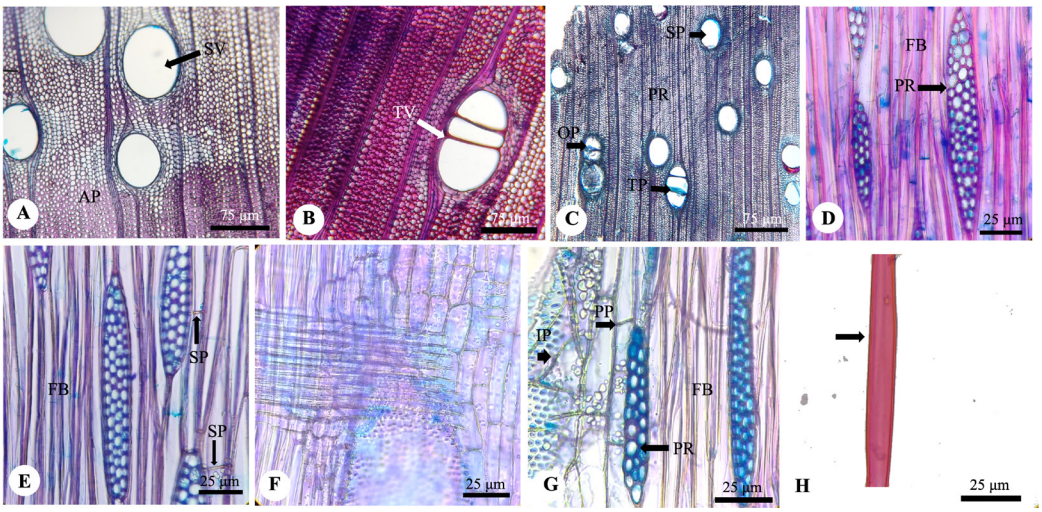


Figure 1 - A: Cross-section showing aliform parenchyma (AP) with solitary vessels (SV); B: Detail of the twinned vessel (TV); C: Tangential section showing paired pores (TP), solitary pore (SP), obstructed pore (OP), and axial parenchyma (PR); D: Tangential section showing PR surrounded by fibres (FB); E: Tangential section showing septum (SP) of the FB and PR; F: Radial section; G: Tangential section showing the perforation plates (PP), inter vessel pits (IP) and fibres (FB); H: Libriform fibres obtained in the maceration process.

encompassing 18.88 cells. The average fiber length was determined to be 1074.69 µm, while average width, diameter and cell wall thickness were 28.5 µm, 20.8 µm and 3.2 µm, respectively. The anatomic characteristics observed align with NISGOSKI et al. (2012). Shorter, smaller-diameter vessels are safer for sap conduction, while longer, larger ones are more efficient (ZIMMERMANN, 1983).

Paricá fibre length was similar to species like *Eucalyptus grandis* and *E. urophylla*, studied by BRISOLA & DEMARCO (2011). However, Paricá's fibre diameter, lumen size, and cell wall thickness were lower. This may explain paricá's lower mechanical strength compared to *E. grandis* and *E. urophylla*, as longer fibres with thicker walls provide greater strength due to a larger cross-sectional area and better interlacement. The 95% confidence t-Student test showed no significant differences in anatomical element sizes between treated and untreated samples.

Moisture content ranged from 46.75% to 75.49% for untreated samples (average 58.26%) and from 50.60% to 71.18% for treated samples (average 61.79%). Bulk density varied between 0.45-0.76 $g.cm^{-3}$ for untreated and 0.52-0.65 $g.cm^{-3}$ for treated samples, with averages of 0.56 $g.cm^{-3}$ and 0.58 $g.cm^{-3}$, respectively. The moisture content difference between treated and untreated samples was 3.53%, with no significant effect of CCA treatment. The high moisture content values in treated samples are justified by the absence of a drying procedure before treatment. A t-Student test (P-value = 0.701) showed no significant impact of CCA on bulk density.

Table 2 shows the mechanical properties of treated and untreated samples. Untreated samples

Table 1 - Fibres, rays and vessels dimensions of paricá wood.

	$Ø_{vessel}$ (µm)	h_{vessel} (µm)	b_{vessel} (µm)	h_{ray} (NC)	b_{ray} (NC)	l_{fibre} (µm)	b_{fibre} (µm)	$Ø_{lumen}$ (µm)	e_{wall} (µm)
Minimum	121.8	22.60	13.14	5.00	2.00	302.46	16.50	16.80	2.10
Average	246.74	229.35	34.32	18.88	3.12	1074.69	28.50	20.80	3.20
Maximum	390.7	517.60	55.30	53.00	4.00	1628.55	39.00	24.10	4.40
SD	74.98	97.33	11.38	9.87	0.60	339.92	5.70	1.95	0.70

Legend: SD: standard deviation; $Ø_{vessel}$: vessel diameter; h_{vessel}: vessel height; b_{vessel}: vessel width; h_{ray}: ray height (number of cells); b_{ray}: ray width (number of cells); l_{fibre}: fibre length; b_{fibre}: fibre width; $Ø_{lumen}$: lumen diameter; e_{wall}: wall thickness.

Table 2 - Mechanical properties result of paricá wood in compression parallel to grain tests.

	----------f_{c0} (MPa)----------		----------E_{c0} (MPa)----------	
	NT	T	NT	T
Maximum	26.91	24.97	11405.17	8403.05
Average	20.70	22.35	8859.48	7531.12
Minimum	16.99	20.15	6195.78	6997.00
f_{ck}	17.40	20.22	-	
SD	4.11	1.92	1737.34	537.85

Legend: NT - untreated series; T - treated series; f_{c0} - compressive strength parallel to grain; f_{ck} - characteristic compressive strength parallel to grain; E_{c0} - modulus of elasticity in compression parallel to grain; SD - standard deviation; CV - coefficient of variation.

had maximum, average, minimum, and characteristic f_{c0} values of 26.91 MPa, 20.70 MPa, 16.99 MPa, and 17.40 MPa, respectively. Treated samples had corresponding values of 24.97 MPa, 22.35 MPa, 20.15 MPa, and 20.22 MPa. E_{c0} values for untreated samples ranged from 6195.78 MPa to 11,405.17 MPa (average 8859.48 MPa), while treated samples had values from 6997.00 MPa to 8403.05 MPa (average 7531.12 MPa). The t-Student test (P-values: 0.401 for f_{c0} and 0.124 for E_{c0}) showed no significant differences between treated and untreated samples. Additionally, the moisture content of 60.02% likely prevented significant changes in mechanical behavior. The lack of influence of CCA treatment in physical and mechanical properties was expected, once ALMEIDA et al. (2019) also observed no changes in *Simarouba amara*, *Cedrelinga catenaeformis*, and *Erisma uncinatum* treated with CCA.

As shown in table 3, after 6 months of exposure, untreated specimens had mass losses ranging from -2.22% to -17.17%, while treated specimens ranged from -0.03% to -1.17%, with total losses of 10.86% and 0.69%, respectively. A 95% confidence t-Student test showed statistical differences between treated and untreated samples since the third month. The CCA treatment significantly improved paricá wood's biological resistance, as treated samples lost less mass (-0.69%) compared to untreated ones (-10.86%). Residual mass loss in treated specimens might be attributed to irregular CCA penetration due to high moisture content in wood before treatment. In fact, the NBR 9480 (ABNT, 2009) standard considers

Table 3 - Average mass loss in each month (%).

Series	----------Months----------						-----Δm----	-----Δm_t----
	1	2	3	4	5	6		
NT1	99.96^a	99.78^a	98.86^a	98.02^a	97.84^a	97.78^a	-2.22^b	-10.86^b
NT2		97.64^a	95.73^a	94.94^a	94.71^a	94.62^a	-5.38^b	
NT3			94.19^b	92.81^b	92.43^b	92.63^b	-7.37^b	
NT4				88.65^b	87.99^b	87.92^b	-12.08^b	
NT5					83.19^b	82.90^b	-17.10^b	
NT6						85.59^a	-14.41^b	
T1	99.65^a	99.89^a	99.85^a	99.66^a	99.36^a	99.28^a	-0.72^b	-0.69^b
T2		99.68^a	99.85^a	99.61^a	99.42^a	99.33^a	-0.74^b	
T3			99.45^b	98.92^b	98.73^b	98.83^b	-1.17^b	
T4				99.35^b	99.19^b	98.96^b	-1.04^b	
T5					99.78^b	99.57^b	-0.43^b	
T6						99.97^a	-0.03^b	

Legend: NT - untreated series; T - treated series; Δm - mass loss in each series; Δm_t - total mass loss; a - statistically equal mass loss between treated and untreated series within the same exposure period; b - statistically different mass loss between treated and untreated series within the same exposure period.

that moisture content shall not exceed 35% for wood subjected to CCA treatment. LOPES et al. (2017) reported mass losses between 5.24% and 76.56% for *C. torelliana* and 4.85% to 49.92% for *E. urophylla x E. grandis* after 28 days of termite exposure, while FARIA et al. (2020) found mass losses of 20.07% to 25.16% in CCA-treated *Hevea brasiliensis* after 5 months of field exposure.

CONCLUSION

The results showed that the minimum CCA retention obtained was 8.18 $kg.m^{-3}$, which complies with Brazilian Standards retention values for fenceposts. No detectable changes in wood anatomy and physical and mechanical properties were found for the conditions used in this research. However, despite the improvement in the biological resistance of paricá wood, the remaining mass loss in the treated samples can be attributed to inhomogeneous CCA distribution in the wood, possibly caused by the high moisture content.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

AUTHORS' CONTRIBUTIONS

All authors contributed equally to the conception and writing of the manuscript. All authors critically revised the manuscript and approved the final version. All authors critically revised the manuscript and approved the final version.

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