

Application of *Careya arborea* Roxb., Bark Dye for Enhanced Wood Surface Aesthetics and ProtectionNaveen Palanisamy Saravanan¹, Swathi Kandasamy², Ashanath Fowmitha Nazeer³, Sumathi Ramasamy⁴Natchiappan Senthilkumar⁵¹⁻²Dr.NGP arts and science college, Coimbatore, Tamil Nadu, India.³⁻⁵ICFRE-Institute of Forest Genetics and Tree Breeding, Coimbatore, Tamil Nadu, India.

Abstract:

This study explores the potential of *Careya arborea* Roxb., bark as a natural dye for wood surface treatment. Bark samples were collected from Sadivayal, Coimbatore, and subjected to hydro-alcoholic extraction using a methanol-distilled water mixture. Phytochemical screening revealed the presence of flavonoids, tannins, phenols, anthocyanins, steroids, and terpenoids. Quantitative analysis showed high levels of phenols (10.47 mg GAE/g), tannins (10.25 mg TAE/g), flavonoids (6.48 mg RE/g), and anthocyanins (2.83 mg/g), indicating strong dyeing potential. The dye was applied to four wood types—*Swietenia macrophylla*, *Shorea robusta*, *Tectona grandis*, and plywood—under normal and bleached conditions in three concentrations (1:10, 1:50, 1:100). Visual colour assessment using the Royal Horticultural Society Mini Colour Chart showed enhanced dye uptake in bleached samples, especially at 1:10 dilution. Results demonstrate that *Careya arborea* bark extract is an eco-friendly, sustainable alternative to synthetic dyes, providing vibrant and durable coloration for wood surfaces.

Keywords — *Careya arborea*, natural dye, wood colouring, colour assessment, Royal Horticultural Society Chart.

I. INTRODUCTION

Natural dyes from plants have become increasingly popular in numerous industries, such as food, pharmaceuticals, textiles, and cosmetics. Some synthetic dyes have been prohibited because they may cause allergy-like reactions or because they are cancer-causing. Plant pigments possess an array of medicinal uses among the all-natural dyes^[1]. There has been renewed interest in natural dyes in recent years because they are eco-friendly, available, cheap, non-toxic, and sustainable. Consequently, natural dyes are being viewed as superior to artificial dyes. Natural plant species are abundant with various colors and characteristics presented by nature^[2]. *Careya arborea* Roxb., otherwise referred to as Wild Guava in English, occurs mostly in tropical Asia. It ranges across Afghanistan, Pakistan, Sri Lanka, Nepal, Myanmar, Thailand, Laos, and Malaysia. This tree is found in the sub-Himalayan tract, from the Jumna River

eastward, and is distributed in moist and dry deciduous forests, grasslands, and plains. It has

dark grey bark and normally peels in thin strips. The bark of *Careya arborea* contains a variety of compounds, including proteins, reducing sugars, alkaloids, steroids, saponins, triterpenes, and flavonoids, based on preliminary phytochemical analysis. Preliminary phytochemical screenings have reported numerous compounds such as alkaloids, steroids, saponins, proteins, reducing sugars, triterpenes, and flavonoids from the bark of *Careya arborea*. Some of the important phytoconstituents such as tannins, terpenoids, cardiac glycosides, anthraquinones, sterols, and phytosterols were identified by employing various solvents (Behera et al. 2012). Triterpenoids, saponins, tannins, and flavonoids have been identified in the stem bark of *Careya arborea* by further investigation. This study focused on coloring various wood using natural dye

extracted from *Careya arborea* Bark and characterization.

II. MATERIALS AND METHODS

A. Collection of plant sample

Barks of *Careya arborea* were collected from a tree located at 10°41'23.3"N latitude and 79°10'12.3"E longitude in Sadivayal, Coimbatore, Tamil Nadu.

B. Extraction of bark of *Careya arborea*

Shade-dried bark (50 g) of *Careya arborea* was weighed and transferred to a beaker. A ratio of around 3:1 (Distilled water: Methanol) of solvent is employed to harvest the extract from *Careya arborea* bark. The extract was made using the boiling method with the temperature maintained at 80°C (keeping in view the boiling points of the solvents) for 6 hours. After this process, the solvents were evaporated, and the *Careya arborea* bark extract was harvested and stored.

C. Phytochemical analysis of the extract of bark of *Careya arborea*

The plant extracts were tested for the absence or presence of different phytochemicals. These are: alkaloids (Mayers test), flavonoids (lead acetate test), tannins (Braymen's test), quinone (HCL test), steroids (H_2SO_4 test), phenols ($FeCl_3$ test), anthocyanins (NaOH test), carbohydrates (Fehling's test), proteins (Ninhydrin test), steroids (H_2SO_4 test), terpenoids (H_2SO_4 test), and glycosides (ammonia test).

D. Estimation of Secondary Metabolites

The estimation of flavonoids, phenolic compounds, tannins, steroids, and anthocyanins follows established biochemical methods. The flavonoid content of extract was determined based on the method of Zhishen et al., (1999) which was measured at 510 nm, and the results were expressed in Rutin equivalents. (RE) Phenolic compounds were quantified using the Folin-Ciocalteu method, with absorbance at 550 nm, The total tannin content was estimated according to Siddhuraju & Manian, (2007), and the results were expressed in Tannic acid

equivalents (TAE)/g sample. Steroid estimation involved stock ferric chloride, sulfuric acid, and cholesterol solutions, with absorbance recorded at 540 nm after 30 minutes. Total Anthocyanin contents of the extracts were estimated spectrophotometrically (UV-1800, Shimadzu, Kyoto, Japan) at 500 nm and the results were expressed as Catechin equivalents.

E. Wood preparation

Three different types of wood—*Shorea robusta* (Sal), *Tectona grandis* (Teak), *Swietenia macrophylla* (Mahogany)—and commercially available plywood were collected from a local timber shop in Coimbatore, Tamil Nadu. The collected wood samples were cut into uniform dimensions of 10 cm in length, 5 cm in width, and 5 mm in thickness using a mechanical saw. The cut pieces were then sanded with 400-grit sandpaper to obtain a smooth surface and washed thoroughly with distilled water to remove surface debris and dust. After cleaning, the samples were air-dried at room temperature to ensure dryness before subjecting them to the natural dyeing process.

F. Colouring of Wood

All wood samples were initially cleaned using tissue paper to remove any dust or surface debris before dye application. Two treatment processes—normal and bleached—were employed to evaluate the effectiveness of the *Careya arborea* bark dye. The dye was prepared in three different dilutions (1:10, 1:50, and 1:100) and applied evenly using a paintbrush, with each concentration applied in two successive coats to ensure uniform coverage. After application, the coated samples were allowed to dry for 15 minutes. Once fully dried, the samples were subjected to two forms of aging tests—thermal aging and daylight aging

G. Visual gradient analysis of the wood

To assess the colour variations across different wood types and treatment conditions, the RHS Mini Colour Chart (2005) was employed as a standard reference tool for visual evaluation, following the method recommended by Tucker et al. (1991).

III. RESULT AND DISCUSSION

A. Collection and Extraction of the sample

The barks of *Careya arborea* were collected from Sadivayal, Coimbatore, Tamil Nadu, which is located at 10°41'23.3"N latitude and 79°10'12.3"E longitude.(Figure 1). The collected samples were rinsed with tap water and finally with distilled water



to clear way adhering pollutants and soil particles. The collected samples were shade dried and used for extraction purpose.

Figure 1. *Careya arborea* bark and collected location

B. Extraction of *Careya arborea* bark

The dried samples were then ground using a mixer grinder weighed in a digital balance, and stored at – 20 °C for further assays 50g of dried samples were then subjected to hydro-alcoholic extraction through boiling method at 80°C for 6 Hrs. Approximately, 36% of extract were yield and stored at 4 °C for further analysis.

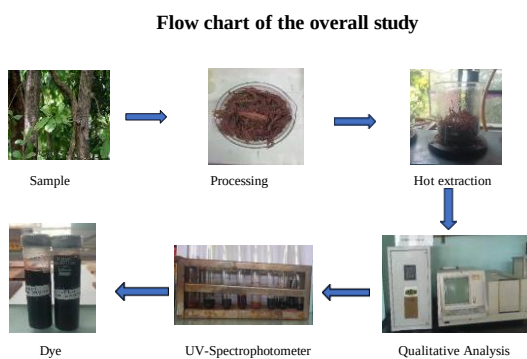


Figure 2. Extraction procedure of *C. arborea* bark dye

C. Qualitative analysis of the extract of bark of *Careya arborea*

The phytochemical screening of the *Careya arborea* bark extract revealed the presence of several secondary metabolites, including flavonoids, tannins, sterols, phenols, anthocyanins, steroids, and terpenoids, (Table.1) while alkaloids, quinones, proteins, carbohydrates, and glycosides were absent. The presence of phenolic compounds and tannins is particularly relevant for wood dyeing, as these metabolites have a strong affinity for lignocellulosic materials, aiding in better dye uptake and colour fixation (Bechtold & Mussak, 2009).

Table 1: Phytochemical analysis of *C. arborea* bark dye extract

METABOLITES	METHANOL
Alkaloids	-
Flavonoids	+
Tannins	+
Quinone	-
Sterols	+
Phenols	+
Anthocyanin	+
Protein	-
Carbohydrates	-
Steroids	+
Terpenoids	+
Glycosides	-

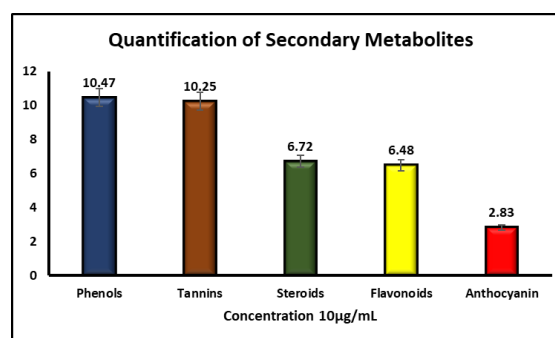
Note: (+) PRESENT; (-) ABSENT

Tannins also act as natural mordants, reducing the reliance on synthetic agents, and thereby supporting eco-friendly dyeing practices. Anthocyanins contribute vivid coloration, especially in red to purple ranges, and enhance the aesthetic quality of wood finishes (Samanta & Konar, 2011). Flavonoids and terpenoids further stabilize the dye molecules and may contribute to antimicrobial and antioxidant properties on treated wood surfaces. The absence of interfering compounds like proteins and carbohydrates suggests a relatively pure extract with favourable characteristics for dye application. Overall, the metabolite profile supports the suitability of this methanolic extract as a natural, sustainable alternative in wood surface colouring.

D. Quantitative Analysis of Bark of *Careya arborea*

The quantification of secondary metabolites in the extract at a concentration of 10 µg/mL revealed phenols (10.47 mg GAE/g extract) and tannins (10.25 mg TAE/g extract) as the major constituents, followed by steroids (6.72 mg/g), flavonoids (6.48 mg RE/g extract), and anthocyanins (2.83 mg CE/g) (Figure 3.) The high content of phenols and tannins is significant for wood dyeing applications, as these compounds have strong binding affinity to cellulose and lignin, enhancing dye fixation and fastness properties (Bechtold & Mussak, 2009). Tannins serve as natural mordants, improving colour intensity and durability without the need for synthetic chemicals. Additionally, the presence of anthocyanins, though in lower concentration, contributes to the colorant profile by imparting vibrant red to purple hues, which are desirable in natural dyeing processes (Samanta & Konar, 2011). The flavonoids and steroids may aid in stabilizing dye molecules and improving the uniformity of color deposition on wooden surfaces. Therefore, the rich composition of these bioactive metabolites underlines the extract's potential as an eco-friendly, multifunctional dye source suitable for sustainable wood coloring and surface treatment applications.

Figure 3. Quantitative analysis of *C. arborea* bark extract



E. Wood preparation and Colouring of wood

Wood samples of *Swietenia macrophylla*, *Shorea robusta*, *Tectona grandis*, and plywood were procured from a timber shop in Coimbatore, Tamil Nadu and prepared through two treatment processes—normal and bleached—to evaluate the effectiveness of *Careya arborea* bark dye. In the normal treatment, dye was directly applied (Figure 4.), while in the bleached treatment, samples were pre-treated with NaOH for 15 minutes and air-dried prior to dyeing. The dye was applied in three concentrations (1:10, 1:50, and 1:100) and tested for durability through daylight exposure and thermal aging. The dyed woods were compared using RHS (Royal horticultural Society) Chart for the colour measurement using visual method (Figure 5.)



Figure 4. Colouring of Wood



Figure 5. RHS chart for visual analysis

F. Visual gradient analysis using Royal Horticulture Chart Method (RHS) Method.

The RHS Mini Colour Chart (2005) was used to assess colour variations in different wood types under varying treatments, providing a reliable reference for visual evaluation as recommended by Tucker et al. (1991). Among all tested wood samples—Teak 1, Teak 2, Mahogany, White Sal, and Plywood—the 1:10 concentration coating consistently resulted in the highest colour intensity (Figure 6). In Teak 1 and Mahogany, normal wood samples showed more intense coloration than bleached ones, particularly under daylight exposure, likely due to natural extractives offering UV resistance. Conversely, in Teak 2, White Sal, and Plywood, bleached samples exhibited greater colour intensity, especially when subjected to both daylight and thermal aging, suggesting enhanced pigment absorption post-bleaching. These results highlight the effectiveness of the RHS chart for wood colour assessment and underscore the influence of wood type, surface condition, and environmental exposure on final coloration.

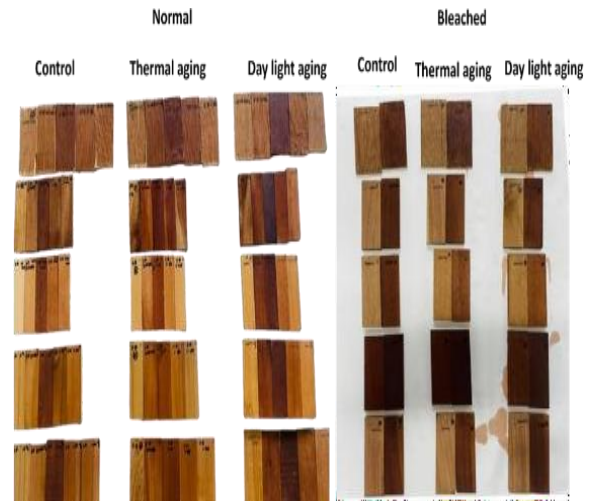


Figure 6. Dyed Wood samples

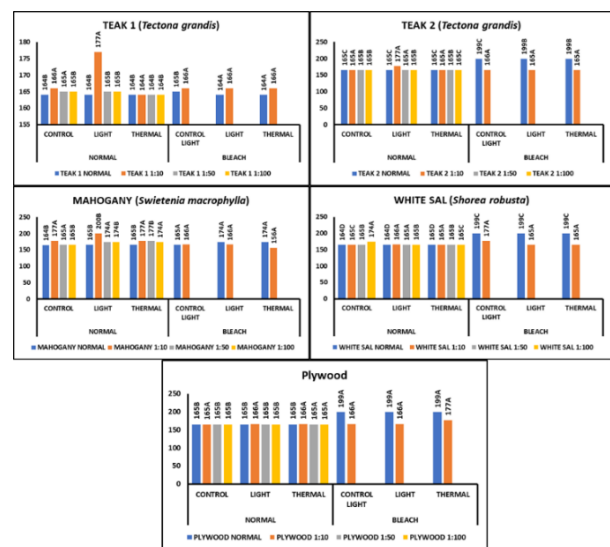


FIGURE 7: RHS GRADIENT ANALYSIS

IV. CONCLUSIONS

The present study highlighted the successful extraction and application of *Careya arborea* bark dye as a sustainable natural colorant for wood surface treatment. The bark collected from Sadivayal, Coimbatore, Tamil Nadu yielded a hydro-alcoholic extract rich in phenols (10.47 mg GAE/g), tannins (10.25 mg TAE/g), flavonoids, steroids, and anthocyanins, which are crucial for effective dye adherence, colour fixation, and durability. Wood samples of *Swietenia macrophylla*, *Shorea robusta*, *Tectona grandis*, and plywood treated under both normal and bleached conditions showed significant coloration, with 1:10

concentration producing the most vibrant results. The RHS Mini Colour Chart effectively quantified colour differences, revealing that bleached samples generally exhibited enhanced dye uptake and stability, particularly under thermal and daylight aging. This study demonstrates that *Careya arborea* bark extract is a promising eco-friendly alternative to synthetic dyes, offering both aesthetic appeal and functional benefits in natural wood colouring applications.

V. ACKNOWLEDGMENT

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