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Analysis of Changes in Vessel Cells of Meranti and Bangkirai Wood Placed Outdoors

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Abstract. Wood, as a renewable material, can be used for indoor and outdoor products. Meranti and Bangkirai as commercial woods, are used outdoors. The wood used outdoors will experience wood cell damage and discoloration on the surface. The research aims to determine the pattern of damage and discoloration of wood vessel cells in Meranti and Bangkirai wood due to weather exposure for 5 months in Samarinda. The wood cell damage was observed microscopically, and changes in wood vessel cells colour were observed using the CIE lab method on parameters L*, a*, b*, and ΔE. The study's results showed that after being exposed to the weather for 2 months, the vessel cells of Meranti and Bangkirai wood began to experience degradation. In Meranti wood, the vessel cells were completely degraded and left cracks after 4 months, while in Bangkirai wood, it was 5 months. After being exposed to the weather for 5 months, Meranti wood vessel cells experienced changes in the parameters ΔL -10.65, Δa -14.68, Δb -12.89, and ΔE 22.25. While Bangkirai, ΔL -7.01, Δa -12.84, Δb 15.95 and ΔE 21.64.

1 Introduction

Wood is one of the world's most abundant and sustainable renewable resources [1]. Wood can be used for indoor and outdoor purposes. Wood is commonly utilised in many applications such as outdoor furniture, agricultural equipment, and transportation equipment [2]. The lifespan of wood used outdoors is roughly 50 years [3].

Most of the commercially important timber in Indonesia dominated by dipterocarp trees [4]. Dipterocarp timber, particularly Meranti and Bangkirai, is suitable for both indoor and outdoor applications. The roofs of the traditional houses of the Sakai tribe in Sumatra are constructed with Meranti timber, illustrating its use for outdoor purposes [5]. While Bangkirai wood is used outdoors in the form of wooden flooring [6]. Especially in East Kalimantan, Meranti, and Bangkirai, wood is used as garden furniture, fences, and house

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walls. Even though Meranti and Bangkirai belong to the Shorea genus, their use is considered to be different because the quality of the wood is considered to be different [7].

When used outdoors, wood will be affected by temperature, sunlight, rain, humidity, and other weather factors. The surface of outside wood is susceptible to degradation as a result of exposure to weather conditions, leading to alterations in the colour of the wood surface [8]. Wood surfaces can absorb 30-100% of sunlight, which can change the chemical composition and structure of wood cell walls [9]. Due to the presence of light-absorbing substances including lignin, chlorophyll, and tannins, wood has a brownish hue [10]. Wood exposed to weather can be attacked by fungus [11].

This damage to the surface of the wood is known as discolouration. Discolouration actually begins with changes that occur at the wood cell level [12], which then results in damage to the wood cells on a macroscopic scale, leaving a crack pattern. The phenomenon of wood discoloration is known to have a negative impact on the visual appeal of wood, leading to a subsequent decline in its aesthetic value. Ultimately, this deterioration in aesthetic quality results in a reduction of the economic worth of the wood, often leading it to be categorized as a lower grade material [13]. The phenomenon of wood discoloration is observable to the naked eye [14]. Specifically, wood color discoloration is measured using the CIE Lab method [15], with the parameters include brightness (L*), the red-green axis (a*), and the yellow-blue axis (b*). The wood discolouration pattern exhibited by each species is highly distinctive. The research aims to determine cell damage on the surface of wood, color changes and the presence of attacks by wood-destroying microorganisms on Meranti and Bangkirai timber exposed to the weather in Samarinda for five months.

2 Materials and Methods

The purchase of the red meranti planks was made at a lumberyard in Samarinda. 30 centimeters long, 15 cm wide, and 2 centimeters thick were the final measurements. The wood sample underwent macroscopic examination and colorimetric analysis to determine its color every 30 days until 150 days.

The wood is examined under a microscope every 30 days until 150 days to check for alterations in the vascular cells. Using the GIMP program, the wood color parameters L, a, b, and ΔE were observed. Colour changing (ΔE) counted by Equation (1) :

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

Information:
ΔE = Color difference
ΔL* = Brightness difference = L* nth month exposure sample – L* sample before exposure
Δa* = Red or green difference = a* month day exposure samples – a* pre-exposure samples
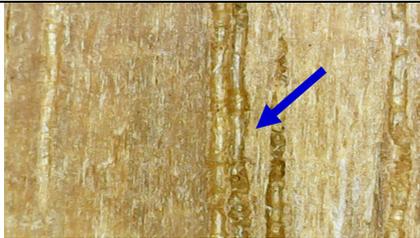Δb* = Yellow or blue difference = b* month day exposure samples – b* pre-exposure samples

The data obtained was analyzed using Excel 365 to obtain graphic images and estimation curves of the measured color parameters.

3 Results and Discussion

The anatomical structure of the Meranti and Bangkirai sample test woods and results of microscopic observations on wood test samples after weathering test can be seen in the Table 1.

Table 1. The anatomical structure of the Meranti and Bangkirai sample test woods.

Anatomical characteristics	Meranti	Bangkirai
Pores cells	Round shape, radial solitary and double groups, diagonal pattern arrangement, diffuse porosity.	Round and oval in shape, radial solitary and double groups, diagonal pattern arrangement, intermixed porosity
Parenchyma cells	Rare paratracheal	Unilateral paratracheal bands are short tangential bands
Rays cells	Heterogeneous, multiseriate	Heterogeneous, biseriate
Fiber cells	Thin cell walls	Thick cell walls
Axial intercellular canals	Not visible	They are surrounded by parenchyma cells

Days	Meranti wood	Bangkirai wood
30	Wood vessel cells begin to change colour to greyish-brown.	Wood vessel cells begin to change colour to greyish-brown.
60	Small holes begin to appear in the vessel cells and the wood cells begin to turn pale.	Small holes begin to appear in the vessel cells and the wood cells start to pale but still have a brownish color.
90	Wood cells became paler.	Wood cells became paler.
120		

150	Degraded vessel cells cause scars in the form of crack patterns.	The vessel cells of the wood begin to degrade, causing cracks that give rise to scars in the form of crack patterns.
	The vessel cells of the wood have degraded and left cracks in the wood.	The vessel cells of the wood have degraded and left cracks in the wood.

Bangkirai has smaller vessel cells compared to light red meranti [16]. Changes in temperature, air humidity, and sunlight on the surface of the wood result in the delignification and leaching of the wood cell colour, which becomes pale grey [17]. Weather exposure progressively alters the color of the wood and the presence of UV rays can degrade wood cell walls, causing wood cracks [18] without changing the cell size. Exposure to weather can break down the tyloses in wood vessel cells, causing holes in the vessel cell walls, and it will decay the wood vessel cells in the long term [19].
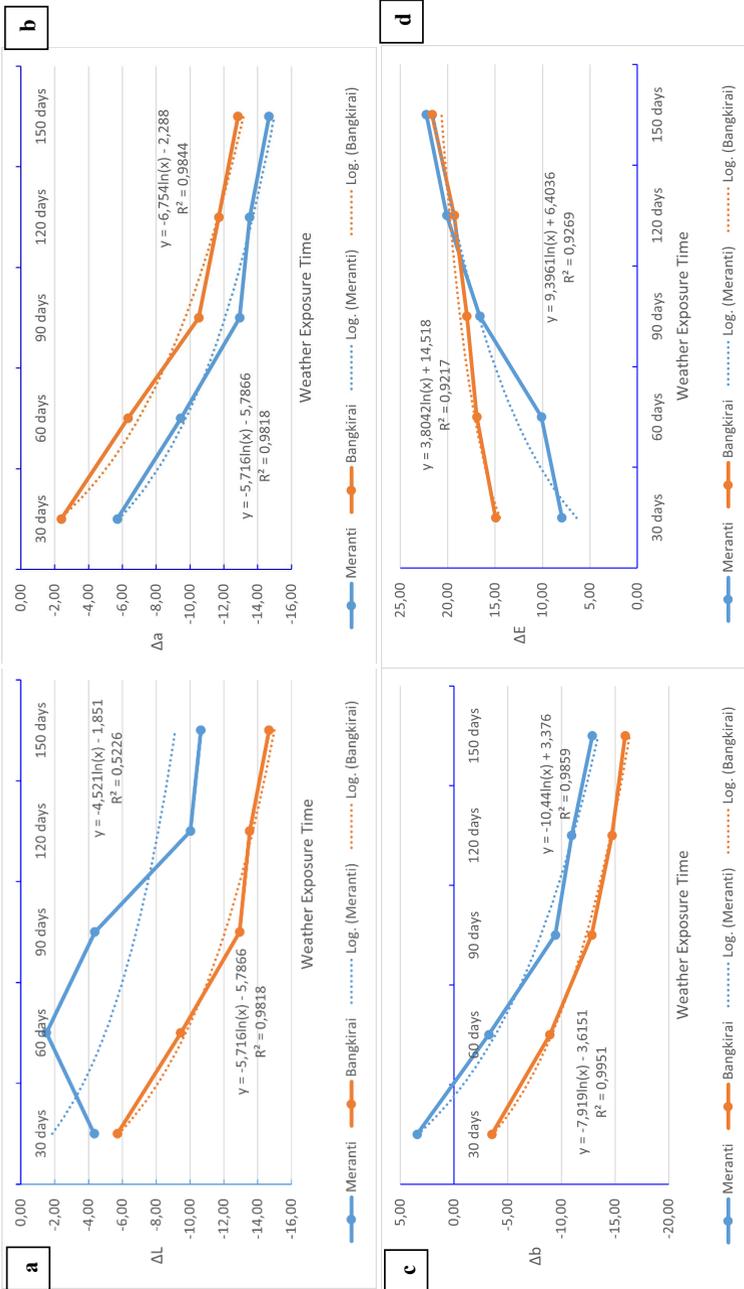
The brown spots on the surface of Bangkirai wood are wood extractives that come out from inside the wood onto the surface of the wood [20]. Exposure to weather can release phenolic compounds into the surface of the wood [21]. Bangkirai extractives contain phenolic compounds [22]. The results of observing wood color using GIMP software from CIE Lab on the parameters ΔL, Δa, Δb and ΔE, can be seen in the Fig. 1.

Until up to 6 months, when placed outdoors, tropical wood tends to experience changes in ΔL, so the wood becomes pale macroscopically [23]. Wood with a high specific gravity tends to have a larger ΔL value [24]. In uncoated wood, the Δa value tends to increase while it is outdoors for up to 1 year [25]. In uncoated wood, the Δb value tends to have a negative value while outdoors for up to 1 year [25]. The ΔE value decreased with the increasing weathering time. The initial color change tends to be higher, and the speed of color change tends to decrease with the length of time exposed to outdoor weather [18].

On Bangkirai wood, no wood-destroying fungal hyphae attacks were found. In contrast, the results of microscopic observations of fungal hyphae attacks on Meranti wood can be seen in the Fig.2.
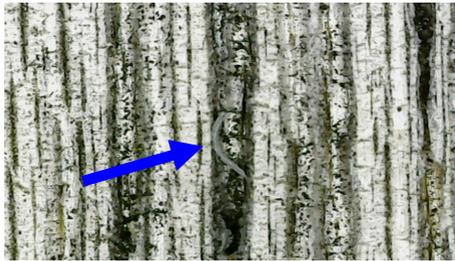
Bangkirai is regarded as high-quality wood because of its excellent biological endurance features [26]. Due to the comparatively high specific gravity of Bangkirai wood, fungi have a more difficult time surviving on it [27]. Bangkirai wood contains phenolic extracts [20] that are toxic to fungi. Rot fungi can quickly attack light red meranti [28].

Rainwater that falls on the wood's surface will saturate and leach the wood. The process of water-leaching makes red meranti wood more susceptible to decay fungi [29]. Red meranti is more easily attacked by fungi than bangkirai wood because bangkirai wood has less polysaccharide components [30]. The presence of fungal attacks on meranti wood in the long term can reduce the physical and mechanical quality of the wood [31].

Fig. 1. a. ΔL Meranti and Bangkirai wood for 150 days, **b.** Δa Meranti and Bangkirai wood for 150 days, **c.** Δb Meranti and Bangkirai wood for 150 days, **d.** ΔE Meranti and Bangkirai wood for 150 days

Meranti wood

Root attack after 120 days

Root attack after 120 days

Fig. 2. Hyphae found in meranti wood

4 Conclussion

After being exposed to the weather for 2 months, the vessel cells of Meranti and Bangkirai wood began to experience degradation. In Meranti wood, the vessel cells were completely degraded and left cracks after 4 months, while in Bangkirai wood, it was 5 months. After being exposed to the weather for 5 months, Meranti wood vessel cells experienced changes in the parameters ΔL -10.65, Δa -14.68, Δb -12.89, and ΔE 22.25. While Bangkirai, ΔL -7.01, Δa -12.84, Δb 15.95 and ΔE 21.64.

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