Oil Palm Wood Vinegar as Wood Preservatives

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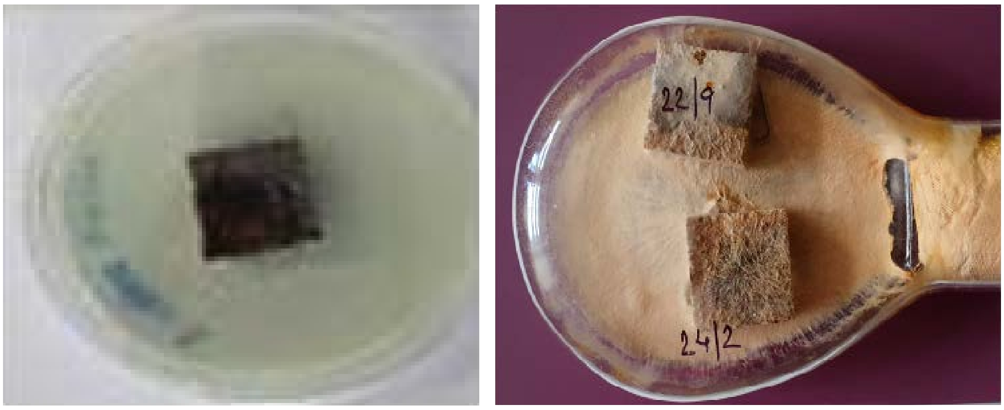
INTRODUCTION

As a sustainable and organic material, wood plays an essential role in numerous industries, particularly in construction and furniture (Iždinský *et al.,* 2021). However, due to high-volume demand for this renewable raw material, lack in wood supply is set to become a critical issue in the future (Fiorelli *et al.*, 2019). Therefore, oil palm wood (OPW) extracted from felled oil palm stems is an ideal substitution for the depleting timber resource and could potentially alleviate deforestation. Oil palm trunks and fronds, for example, have been used for particleboard production (Sulaiman *et al.,* 2018).

A variety of abiotic factors, such as wind, dust, rain, and sunlight, can deteriorate cause wood. Furthermore, it is subject to deterioration by microorganisms including fungi, bacteria, and termites (Sun *et al.,* 2022). The hygroscopic nature of wood may cause it to absorb water and atmospheric moisture, creating dimensional changes that cause the wood to cup, warp, and crack (Chau *et al.,* 2018). If the right circumstances are present, living things, such as fungus, moulds and insects, can consume the nutrients found in their parenchyma or structural components, thus shorten its lifespan. This aspect is ecologically and economically significant as the need to replace faulty wooden components reduces wood's competitiveness against other building materials.

Additionally, wood decays when combined with building restrictions such as fire code, and can severely restrict its usage as building material (Teacă *et al.,* 2019). Wood decay fungi can be categorised into three major categories based on their ability to biomineralize wood's major structural components, including cellulose, lignin, and hemicelluloses: White, brown, and soft decay (*Figure 1*). Additionally, less dangerous fungi and moulds can damage wood, reducing the aesthetic value of wood and wood products (Schmidt *et al.,* 2016). *Coniophora puteana*, *Gloeophyllum trabeum*, and *Laetiporus sulphureus*, among other members of the phylum Basidiomycetes, are brown rot fungi that may degrade wood polysaccharides but only partially alter lignin, producing brown material made of oxidised lignin (Brischke and Alfredsen, 2020). Contrarily, lignin is degraded by white rot fungi such *Trametes versicolor*, *Heterobasidion annosus*, and *Xylaria polymorpha*, giving decaying wood a whitish colour and fibrous texture (Adfa *et al.,* 2020). Most of the soft rot fungus are Ascomycota species that attack wood in two ways; forming distinctive cavities in the cell walls (type I), erosion of cell wall to hyphae situated in the cell lumina (type II). Blue strain fungi like *Ophiostoma piceae* and *Lasiodiplodia theobromae*, as well as moulds like *Aspergillus niger*, *Aspergillus versicolor*, *Penicillium brevicompactum*, degrade the wood's nutrient reserves (mostly wood extractives and water-soluble components), but they do not significantly damage the wood structure (Pasanen *et al.,* 2000).

Various processes and techniques, such as chemical processing (furfurylation or acetylation), thermal modification, or impregnation with numerous substances and chemicals, were used to increase the service life of wood and wood products (Sandberg *et al.,* 2017; Wang *et al.,* 2018). Almost all wood preservatives such as fungistatic or fungitoxic substances, including oil-based preservatives such pentachlorophenol or creosote (Engwall *et al.,* 1999) and waterborne wood preservatives, contain copper as biocide (Borges *et al.,* 2018). However, majority of the existing wood preservatives imposed significant environmental risks due to their toxicity. Copper chromate arsenate (CCA) is an example of this water-borne preservative and is generally prohibited due to the potential environmental and health concerns when in contact with skin (Lin *et al.,* 2009). Due to environmental



(a) (b)

Source: (a) Iždinský *et al*., 2021.
(b) Hamid *et al*., 2022.

Figure 1. (a) Brown rot and (b) white rot fungi.

concern of toxic chemicals, increased political pressure, and efforts to mitigate climate change and other global sustainability issues, chemicals legislation in Europe and North America is gradually limiting the use of traditional wood preservatives based on formulations typically containing heavy metals (Broda, 2020). The Biocidal Product Regulation (EU 528/2012) governs the application of wood preservatives in Europe. Human health concerns or ecological problems may result in limited number of traditional wood preservatives accessible in this industry (Järvinen and Ilgın, 2022).

As a result, new wood preservatives with little environmental impact such as plant-based chemicals, essential oils and their components, plant extracts, phenolic compounds, and alkaloids, have been studied as potential antifungal agents in wood protection (Cai *et al.,* 2020; Xie *et al.,* 2017). Animal-based chemicals, such as beeswax, chitosan, and snail peptides, have also been explored as antifungal agents that could enhance the durability of wood (Woźniak, 2022). Due to the impending need, numerous scientists are exploring, with some success, the antifungal properties of various bio-based compounds, such as mistletoe and lichen extracts (Yildiz, 2020), coffee-related waste extracts (Ochoa-retamero *et al.,* 2018), propolis extracts (Akcay *et al*., 2020) and vegetable and fruit peel extracts (Ochoa-retamero *et al.,* 2018).

Natural resource materials, such as wood vinegar and bamboo vinegar are not used in wood industries worldwide, but as folk medicine for skin diseases in Japan (Velmurugan *et al.,* 2009). Wood vinegar is often employed as animal feed addition, odour eliminator, or anti-inflammatory agent due to its antioxidant, antibacterial, and anti-termite characteristics (Winarni *et al.,* 2021). Wood vinegar is an acidic liquid product with a pH range of 2-4 and has significant biocompatibility; its natural antioxidant and antimicrobial properties are primarily attributed to its acidic, phenolic, and ketonic constituents (Mathew and Zakaria, 2015). The main source of acids and ketones in biomass is from the degradation of hemicellulose and cellulose (Lee *et al.,* 2018), while phenols are typical products from the decomposition of lignin (Li *et al.,* 2022).

Figure 2. Oil palm wood vinegar from carbonisation process for charcoal production.

Ariffin *et al.,* (2017) demonstrated that optimised wood vinegar generated from palm kernel shell under optimal conditions, *i.e.,* with maximum total phenolic content, has excellent potential for antibacterial and antibiofilm applications. In addition, Oramahi *et al.,* (2018) examined the antifungal and antitermite effects of oil palm trunk-derived wood vinegars. Results showed that while there was antifungal action against *T. versicolor*, higher concentrations were needed to prevent the growth of *F. palustris*. Furthermore, the results showed that there were antitermite activities against *C. formosanus*.

CONCLUSIONS

Wood preservation can be accomplished by applying various wood preservatives or subjecting the wood to thermal or chemical modifications. In general, wood preservatives can provide biological resistance, whereas modifications can improve the physical qualities of wood by altering the chemical composition of the lignocellulose component. In addition, the use of lignocellulose by-product of oil palm could reduce environmental pollution caused by their disposal or combustion. In recent years, research on the utilisation of oil palm lignocellulose biomass, a sustainable bioresource to produce wood vinegar with numerous applications, has garnered attention. The most recent advances in thermochemical chemistry could enhance the exploitation of lignocellulosic materials, making the process more cost-effective.

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