

WOOD

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2024

Wood 4 Sustainability

Processing, Construction, Products and Design

2024

Főszerkesztő: Dr. Csiha Csilla

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Processing, Construction, Products and Design

2024



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Főszerkesztő

Dr. Csiha Csilla Mária

Szerkesztők

Prof. Dr. Kósa Balázs, Prof. Dr. Magoss Endre, Dr. habil. Németh László

Lektorok

Gerencsér Kinga Címzetes Egyetemi Tanár, Szabadhegyi Viktor Címzetes Egyetemi Docens,
Prof. Dr. Alpár Tibor, Prof. Emeritus Tolvaj László, Prof. Dr. Markó Balázs

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Hiba Khalifa^a, Róbert Németh^a

^a University of Sopron, Faculty of Wood Engineering and Creative Industries, Bajcsy-Zsilinszky. u. 4., Sopron, Hungary.

Email: hibakhalifa92@gmail.com, nemeth.robert@uni-sopron.hu

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ABSTRACT

This review takes a closer look at the differences between the barks of deciduous and coniferous trees, focusing on their structure, chemical makeup, and ecological roles. Deciduous trees typically exhibit a thinner bark structure with distinct layers, including an outer protective layer and an inner phloem responsible for nutrient transport. In contrast, coniferous trees possess thicker, more uniform bark enriched with resin ducts that enhance defense against environmental stressors. The chemical composition of bark varies significantly between these two groups; deciduous barks are rich in tannins and flavonoids, while coniferous barks contain higher concentrations of terpenes and resins. Ecologically, both types of bark play vital roles in supporting biodiversity and contributing to soil health. This review highlights the importance of understanding these differences for effective forest management and conservation strategies, furthermore, it also points out differences in utilization opportunities.

Keywords: Bark - Deciduous trees - Coniferous trees - Structural differences, Industry, innovation and infrastructure

1. Introduction

Tree bark is a crucial component of arboreal biology, serving multiple functions beyond protection. As the outer layer, bark shields inner tissues from pests, pathogens, and environmental threats. Its complex structure includes a phloem and a protective cork layer, enabling trees to adapt to changing conditions, essential for survival. Bark varies significantly among species in texture, color, thickness, and chemical composition. For example, the American beech has smooth bark

throughout its life, while others develop rough surfaces with age. These textures, ranging from flaky to scaly, not only provide protection but also help identify tree species during winter when leaves are absent, and last but not least during primary wood processing (log yards).

Ecologically, bark offers habitats for organisms like lichens and mosses, aids in forest hydrology by capturing rainfall, and mitigates soil erosion. Some trees have evolved specialized bark structures to

withstand specific climates or threats, such as robust bark that helps endure wildfires. The chemical properties of bark influence its color and texture, with tannins in oak trees creating a reddish-brown hue that changes over time. Bark's multiple roles underline its ecological importance and enhance our understanding of forest ecosystems. (Krantz & Davis, 2019; Boulder Tree Care, 2017; Ilek et al., 2016; Arboristnow, 2024; Pásztor et al., 2016).

2. Structural differences

Tree bark exhibits remarkable structural differences between deciduous and coniferous species, each adapted to thrive in their unique environments and fulfill specific ecological roles. Generally, the bark of deciduous trees is thinner and consists of multiple layers, including a protective outer cork layer that defends against environmental stressors like sun irradiation (UV light and infrared), insects, fungal infections and mechanical influences. The texture of this outer layer can vary significantly; for instance, the smooth surface of beech bark contrasts sharply with the rough fissures typically found in oak. Beneath this cork layer lies the inner phloem, which is crucial for transporting nutrients throughout the tree. On the other hand, coniferous tree bark is usually thicker and displays a more uniform structure across different species. For example, the giant sequoia has bark that can approach 1m in thickness, providing substantial protection against fires during critical periods. Additionally, many coniferous species develop resin ducts within their bark, which serve as a defensive mechanism by producing sticky

resins that deter insects infestations and prevent fungal growth. This adaptation not only enhances physical protection but also supports the healing process after injuries. Furthermore, the variations in thickness and texture between deciduous and coniferous barks reflect their adaptations to specific habitats. Thinner bark in deciduous trees allows for more efficient nutrient transport during peak growth periods when photosynthesis is most active. In contrast, thick-barked conifers are better suited to withstand extreme environmental challenges such as droughts or wildfires. The presence of resin ducts further strengthens their defense against herbivory and diseases.

Bark Thickness

Coniferous species like *Pinus taeda* have thicker bark (up to 0.77 cm) compared to deciduous species such as *Prunus serotina* (0.17 cm) (Shearman & Varner, 2021). Bark thickness is often correlated with tree diameter, but growth rates also influence bark allocation (Shearman & Varner, 2021). Other influencing factors are climatic conditions and vertical position measured along the tree trunk.

Rugosity

Rugosity varies among species, with oaks and pines displaying more pronounced rugose bark compared to other species (Shearman & Varner, 2021)

Deciduous Tree Bark

Deciduous trees often have a bark structure that varies with the seasons. The bark is typically composed of multiple layers:

- **Outer Bark (Periderm):** This layer serves as the primary protective barrier against environmental threats. It consists of cork cells that are dead at maturity and provide insulation and waterproofing (Evert, 2006).
- **Inner Bark (Phloem):** This living tissue is responsible for transporting nutrients produced by photosynthesis from the leaves to other parts of the tree. The phloem is crucial for the tree's growth and health (Paolucci, 2020).

The **phellogen** (cork cambium) in deciduous trees is more advanced and shows greater variability. This is partly because dicotyledons represent a more physiologically and morphologically diverse group. The phellogen can renew itself periodically (functioning in cycles) and can produce a thicker, multi-layered periderm. In the periderm of deciduous trees, not only cork cells but also phellogen (a layer of living cells) can develop, providing additional protection and flexibility (Molnár, 2004).

Coniferous Tree Bark

Coniferous trees, or evergreens, possess a different bark structure characterized by:

- **Thick Outer Bark:** The outer bark is often thicker than that of deciduous trees and is composed mainly of dead cells that provide enhanced protection against fire and pests (Hong et al., 2024).
- **Resin Ducts:** Many conifers have specialized structures called resin ducts that secrete resin. This resin serves as a defense mechanism against insects and pathogens (Fahn et al., 2018).
- In conifers, the **phellogen** (cork cambium) generally has a simpler structure and produces fewer cell layers. In these plants, the periderm (secondary dermal tissue) is less differentiated. The phellogen primarily produces layers of cork (suberized cells), which protect the stem and roots (Molnár, 2004).

The bark of coniferous trees tends to be more uniform in texture compared to deciduous trees. For example, the bark of pine trees is typically scaly or plate-like, while spruce trees have a smoother appearance. Ultimately, these structural differences play a crucial role in ensuring the survival of trees within their respective ecosystems by enabling them to effectively manage moisture retention, protect against pests, and adapt to varying climatic conditions.

3. Chemical composition

Secondary Metabolites in Deciduous Trees

Deciduous tree bark contains various secondary metabolites that contribute to its protective functions. These include:

- **Tannins:** These compounds provide resistance against herbivory and microbial attack (Constabel et al., 2014).
- **Flavonoids:** Present in many species, flavonoids contribute to UV protection and may deter pests (Sillero et al., 2021).
- **Lignin and Extractives:**
 - Deciduous barks, such as those from alder and oak, exhibit high lignin content, with alder showing the

highest levels among deciduous species (Özgenç et al., 2017).

- Extractive content varies, with hardwoods generally having lower polysaccharide levels compared to lignin and extractives (Vangeel et al., 2021).

Figure 1 shows a pest-repellent chemical secreted by bark. Research indicates that the concentration of these compounds can vary significantly depending on environmental factors such as soil quality and climate (temperature, precipitation, and sunlight) (Chrabąszcz & Mróz, 2017), geographic location/altitude, tree age, and the presence of pests or diseases.

Secondary Metabolites in Coniferous Trees

Coniferous tree bark is rich in terpenes and resins, which play critical roles in defense:

- **Terpenes:** These volatile compounds can deter herbivores through their strong odors.

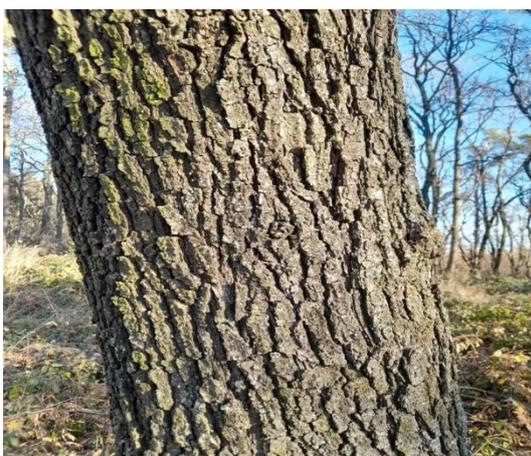


Figure 1. Other trees produce chemicals in their bark to make them unpalatable or to ward off competition from other tree species. (*Quercus* sp.). (photo: Németh R., 2024)

- **Resins:** As mentioned earlier, resin production is a key defense strategy against pests and pathogens. The composition of resin can vary widely among species and even within individuals depending on stress conditions (Rissanen et al., 2019).
- **Lignin:** Coniferous barks, like cedar and fir, also contain significant lignin, with cedar having the highest content among conifers (Özgenç et al., 2017).
- **Phenolic Compounds:** Coniferous barks have been found to contain higher total polyphenol content, contributing to their antioxidant properties.

The antioxidant activity of bark extracts varies significantly, with coniferous species often exhibiting stronger activity compared to deciduous ones. The chemical composition of conifer bark often results in a higher resistance to decay compared to many deciduous species (Sarkhad et al., 2022).



Figure 2. Grey poplar (*P. x canescens*) carries out photosynthesis through its bark when other deciduous trees are dormant. Grey poplar stands in Hungary. (photo: Németh R., 2023)

4. Ecological roles

Role in Ecosystem Dynamics

Both deciduous and coniferous barks play essential roles in their respective ecosystems:

- **Habitat for Organisms:** The rough texture of some deciduous barks provides habitats for various organisms, including insects and epiphytic plants. In contrast, coniferous barks often host fungi that contribute to nutrient cycling.
- **Soil Enrichment:** As both types of trees shed their bark over time, they contribute organic matter to the forest floor. This organic matter enhances soil fertility and supports diverse plant communities.

Additionally, bark-dwelling beetles and other inhabitants contribute to decomposition by creating pathways through the bark, allowing fungi to penetrate deeper wood sections. This symbiotic relationship accelerates nutrient recycling within forest ecosystems, making decaying organic matter available to plants and other organisms. Bark has other distinct functions, such as that of the grey poplar (*P. x canescens*), this species utilizes its bark for photosynthesis, a crucial adaptation during dormancy when other deciduous trees are leafless (Figure 2). This highlights the functional plasticity of bark beyond its protective role.

5. Future research directions on tree bark studies

Future research on tree bark should focus on several key areas to deepen our

understanding of its ecological and biological significance. First, investigating the microbial communities associated with bark is essential, as these ecosystems support diverse microorganisms influenced by tree species, age, and environmental conditions. Utilizing advanced metabarcoding techniques can help explore these communities across different forest types and management methods, revealing their roles in forest biodiversity.

Additionally, the chemical composition of bark remains largely unexplored. Initial findings suggest that secondary metabolites like tannins and flavonoids play crucial roles in plant defense and interactions with other organisms. A comprehensive study of the metabolic pathways for these compounds, including variations due to species and growth conditions, is needed.

Moreover, structural characteristics of bark warrant further investigation. Understanding how factors such as tree age and species traits affect bark thickness can enhance our knowledge of its protective functions against biotic and abiotic stressors. This knowledge, combined with ecological modeling, may provide insights into how different bark types influence microhabitat complexity and biodiversity. The role of inner bark ecosystems is another under-researched area. Studying endophyte communities within inner bark could illuminate their contributions to tree health and resilience against pathogens. Future studies should prioritize high-quality samples from diverse tree species.

Finally, assessing the effects of climate change on bark properties is critical, as shifts in temperature and precipitation patterns may impact bark structure,

composition, and associated microbial life. Interdisciplinary approaches combining genomics, transcriptomics, and metabolomics will enrich our understanding of evolutionary processes in bark tissues and enable biotechnological applications (Pellitier et al., 2019; Dossa et al., 2016; Dreyling et al., 2022; Stängle et al., 2017).

5. Conclusion

Examining the bark of deciduous and coniferous trees reveals significant structural and chemical differences that influence their ecological roles. Deciduous trees have thinner bark, promoting rapid growth and nutrient uptake in optimal conditions. In contrast, the thicker bark of conifers protects against fires and pests. Chemically, deciduous tree bark is rich in tannins and flavonoids, which help defend against threats and enrich soil through decomposition. Coniferous bark contains terpenes and resins that offer antimicrobial benefits and deter herbivores by concealing feeding sites.

Ecologically, these barks contribute differently to their environments. The

thinner bark of deciduous trees enhances nutrient cycling by facilitating microbial interactions during decomposition. Conversely, the thick bark of conifers supports biomass accumulation and carbon sequestration, contributing to soil stability. Biodiversity is also affected; deciduous species attract a wider variety of arthropods due to their softer texture, while coniferous bark creates niches for specialized organisms adapted to harsher conditions. Additionally, both types of bark have potential uses: deciduous bark is valuable for its polyphenolic compounds in pharmaceuticals and food, whereas coniferous bark's high resin content is increasingly recognized for biorefinery applications.

In summary, understanding these comparative characteristics highlights the crucial roles of both deciduous and coniferous barks in forest ecosystems and underscores the need for tailored forest management strategies that appreciate these differences (Pásztor et al., 2016; Özgenç et al., 2017; Dossa et al., 2016; Oka et al., 2021; Miranda et al., 2013).

Author statement

Hiba Khalifa – author, writer.

Róbert Németh – writer, head of the research and Supervisor.

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