

Research Article

Systematic Literature Review: The Workability Properties of *Pinus patula ssp. tecunumanii* and Its Potential in Wood-Based Industries

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Abstract

Pinus patula ssp. tecunumanii is a tropical pine species that is becoming recognized in wood-based industries for its superior workability and adaptability to various settings. This review analyzes the principal workability characteristics of this species, encompassing machinability, grain structure, nail and screw holding capacity, finishing quality, and its appropriateness for engineered wood products. It mainly focus the combination of a domain-based review and a framework-based review to develop a rigorous and transparent systematic review, the "Scientific Procedures and Rationales for Systematic Literature Reviews" protocol.

The species demonstrates excellent machinability owing to its moderate density and straight grain, which enable easy cutting, shaping, and reduced tool wear. The grain structure, predominantly linear and consistent, improves stability during processing and guarantees a superior finish, rendering it suitable for both structural and ornamental uses. *Pinus patula ssp. tecunumanii* demonstrates significant promise for application in engineered wood products such as plywood and medium-density fiberboard (MDF), due to its homogeneous texture, which facilitates robust adhesive bonding and endurance. Its modest bending strength renders it appropriate for applications necessitating shaping, such as bentwood furniture and architectural components. Its intermediate density achieves equilibrium between durability and process ability, rendering it a suitable material for various industrial applications. Generally, *Pinus patula ssp. tecunumanii* is a valuable species for wood-based industries, delivering a mix of machinability, finish quality, and structural integrity while being adaptable to varied climates. Its potential for usage in sustainable forestry and wood production makes it a promising resource for the future of the industry. Further research and development could boost its utilization, supporting both economic and environmental aims. *Pinus patula ssp. tecunumanii* could be a high-potential resource that bridges the gap between the sustainability of tropical pines and the high-performance requirements of modern wood industries. By providing a consolidated framework of its workability, this review serves as a critical guide for industry adoption and highlights the need for real-world pilot testing in diverse tropical processing environments. It also fills knowledge gaps by integrating workability data and guiding future research and industry uptake. Further experimental researches are needed to establish its effectiveness under varied climatic and processing circumstances, boosting sustainable use in the wood-based industry.

Introduction

Pinus patula ssp. tecunumanii is a tropical pine species native to Central America, mainly found in highland parts of Guatemala and southern Mexico [1]. In recent years, this species has attracted substantial attention for its resilience to varied climates and settings, notably in tropical and subtropical locations [2]. As the global need for sustainable wood products develops, *P. patula ssp. tecunumanii* is developing as a viable choice for wood-based industries, including furniture production, building, and engineered wood products [3].

One of the most remarkable aspects of *P. patula ssp. tecunumanii* is its exceptional workability, which relates to how easily the wood can be machined, molded, and finished. This feature is crucial in establishing its applicability for various uses in the woodworking industry. The species is characterized by a straight grain, moderate density, and a consistent texture, all of which contribute to its good machinability [4]. These qualities enable seamless cutting and shaping, resulting in little tool wear and waste throughout production. Additionally, its constant grain structure helps

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Keywords: *Pinus patula ssp. tecunumanii*; Workability; Machinability; Wood-based industries; Engineered wood products; Finishing properties; Tropical pine; Sustainable forestry





eliminate concerns like splintering or warping, making it a great choice for precision woodworking projects [5].

Moreover, the wood’s ability to hold adhesives well adds to its popularity for construction and joinery applications. With a robust capacity for holding nails and screws without splitting, *P. patula ssp. tecunumanii* can be employed in a variety of structural components, assuring the integrity and durability of the finished products [6]. The species also exhibits exceptional finishing capabilities, allowing for smooth, even surfaces when stained, painted, or varnished. This feature boosts its appropriateness for aesthetic applications, such as cabinetry and decorative woodwork, where appearance is vital [7].

In the context of engineered wood products, *P. patula ssp. tecunumanii* is particularly notable. Its moderate density and homogeneous texture provide good adhesive bonding, making it a significant resource for products like plywood, medium-density fiberboard (MDF), and laminated beams [8]. The species’ moderate bending strength allows it to be sculpted into numerous forms, further boosting its usefulness in modern building and furniture design. The species’ moderate bending strength enables shaping applications, boosting its versatility for furniture and architectural usage.

Compared to other economically significant pine species, such as *Pinus radiata* and *Pinus taeda*, *P. patula ssp. tecunumanii* offers equivalent or superior workability, coupled with the added benefit of surviving in tropical settings where other pines may struggle [9]. Its qualities make it an attractive choice for sustainable forestry and wood-based enterprises.

Methods

This study uses a systematic literature review to examine the existing literature studies on the workability features of *Pinus patula ssp. tecunumanii*. The method involves numerous steps designed to ensure a full grasp of the species’ characteristics and its potential in wood-based industries.

In this literature review, a combination of a domain-based review (Paul & Criado, 2020) and a framework-based review (Paul & Benito, 2018) was used. To develop a rigorous and transparent systematic review, the “Scientific Procedures and Rationales for Systematic Literature Reviews” (SPAR-4-SLR) protocol was used (Paul et al., 2021). The SPAR-4-SLR protocol comprises three stages (i.e., assembling, arranging, and assessing) and six sub-stages (i.e., identification, acquisition, organization, purification, evaluation, and reporting). A systematic literature review search was undertaken across numerous scientific databases, including Google Scholar, Scopus, Web of Science, and ResearchGate. Keywords such as “*Pinus patula ssp. tecunumanii*,” workability properties,” “wood machining,” “engineered wood products,” and “wood finishing” were applied to discover relevant studies. The search focuses on peer-reviewed publications, technical reports, conference proceedings, and dissertations published between 1990 and 2024 (Table 1).

Table 1: Summary of database search keywords and records retrieved.

Database	Search Keywords / Boolean Strings	Records Retrieved
Google Scholar	" <i>Pinus patula ssp. tecunumanii</i> ", workability, machining, engineered wood	50
Scopus	" <i>Pinus patula ssp. tecunumanii</i> " and ("engineered wood, nail holding)	20
Web of Science	" <i>Pinus patula ssp. tecunumanii</i> , finishing, and "bending strength")	15
Research Gate	" <i>Pinus patula ssp. tecunumanii</i> " and ("nail holding" or "screw holding")	9
Total Records	Initial identification	94
Final Selection	Sources meeting all quantitative inclusion criteria	10

Inclusion and exclusion criteria

The selection criteria were carefully set to ensure the inclusion of research that provided quantitative data on the workability features of *P. patula ssp. tecunumanii*. Studies were considered if they addressed features such as machinability, grain structure, nail and screw holding capability, finishing quality, bending strength, and overall appropriateness for engineered wood products.

Exclusion criteria: Studies were excluded if they lacked specific methodology, quantitative data, or focused only on ecological or biological factors. Papers missing detailed data or clear techniques were excluded to maintain the rigor of the evaluation.

Data extraction: Data were methodically retrieved from the selected studies, concentrating on important workability metrics and additional variables such as tree age, geographic origin, and climatic influences when available. This data extraction sought to compile quantitative values relating to machinability (cutting ease and tool wear), nail and screw holding capacity, finishing quality (absorption rates and surface smoothness), and other relevant workability parameters.

A comparative analysis was done to benchmark *Pinus patula ssp. tecunumanii* against other commercially relevant pine species, such as *Pinus radiata* and *Pinus taeda*. This comparison focuses on similarities and variations in workability qualities, highlighting the potential strengths and limitations of *P. patula ssp. tecunumanii* for similar industrial applications. Such analysis was vital for showing its competitiveness within the framework of wood-based industries.

The findings from the literature were consolidated to provide a full assessment of the workability qualities of *Pinus patula ssp. tecunumanii*. The review reveals gaps in the available literature, particularly with experimental investigations that measure its performance in real-world situations. This synthesis intends to influence future research paths and foster a better knowledge of how the species might be employed in sustainable forestry and wood-based industry processes. Finally, the review stresses the necessity for future experimental investigation on the workability features of *P. patula ssp. tecunumanii*. This includes research that explores



its performance under varied climatic conditions and processing processes, as well as its long-term durability and stability in both indoor and outdoor applications (Table 2).

Results and discussion

Machinability

The workability of *Pinus patula ssp. tecunumanii* is defined by its great machinability, which significantly boosts its usability in wood-based industries. The species exhibits moderate density and a straight grain structure, enabling easy cutting, shaping, and little tool wear during machining processes [2,4,8]. Research reveals that this species generates clean edges and minimum splintering when processed, which contributes to efficiency and reduced waste during production [1,3]. These machinability qualities make *P. patula ssp. tecunumanii* is an excellent candidate for applications demanding accuracy, such as furniture manufacture and cabinetry [1,3,5].

In comparison to other economically relevant pine species, such as *Pinus radiata* and *Pinus taeda*, *P. patula ssp. tecunumanii* offers similar or even superior machinability [4,5,9]. Its low tendency to tear or chip during cutting guarantees that it remains a viable choice for sectors focusing on high-quality outputs [5,6]. The favorable machinability qualities assist not only traditional woodworking processes but also modern production procedures, which typically demand tight quality control and precision.

Grain and texture

The grain and texture of *P. patula ssp. tecunumanii* further enhance its workability [2,4]. The species is characterized by a primarily straight grain with a consistent texture, which is useful during machining and finishing procedures [5,7]. A uniform grain structure lowers the danger of distortion or warping, ensuring reliable performance during processing [4]. Additionally, the even grain contributes to a smoother finish, making the wood appropriate for decorative applications where aesthetics are crucial [7,4,5].

Studies have indicated that straight-grained timbers are

preferred for a variety of woodworking jobs due to their simplicity of machining and finishing [2]. The consistent grain of *P. patula ssp. tecunumanii* allows sanding and polishing, producing high-quality final products that match the aesthetic criteria of current design [4,5]. This quality is especially significant in high-end furniture production and interior design, where visual attractiveness is paramount [2,7].

Nail and screw holding capacity

The wood's capacity to hold fasteners efficiently is another remarkable workability attribute of *P. patula ssp. tecunumanii*. The species exhibits a great ability for holding nails and screws without splitting, making it excellent for numerous construction and joinery applications [5,6]. This ability supports the integrity of buildings and goods where secure attaching is crucial, hence boosting the overall durability of finished items [4,8].

In practical applications, the species may often be nailed or fastened without the requirement for pre-drilling, which speeds assembly operations, especially in large-scale production setups [4,6]. The great holding power of this wood contributes to its reliability in constructing frames, cabinetry, and furniture, where long-lasting performance is vital [5,8]. This characteristic promotes structural integrity and speeds up assembly in large-scale production, typically removing the need for pre-drilling. It creates *P. patula ssp. tecunumanii* is dependable for cabinets, furniture, and construction components [1].

Workability in engineered wood products

Pinus patula ssp. tecunumanii is particularly well-suited for usage in engineered wood products, such as plywood, medium-density fiberboard (MDF), and laminated beams [4,8]. Its consistent texture and moderate density guarantee excellent adhesive bonding, resulting in robust and stable designed products [2,5]. The capacity to adhere well with adhesives is a vital feature in the development of high-quality engineered wood, making this species a significant resource for producers [3,10]. Moreover, its moderate bending strength allows *P. patula ssp. tecunumanii* to be formed into numerous

Table 2: Summary of database search keywords and records retrieved.

Title	Authors	Journal / Publisher	Year	Database/ Source Type
<i>Pinus patula</i> : An Annotated Bibliography	Barnes RD, & Mullin LJ.	Oxford Forestry Institute	2001	Technical Report/ Bibliography
Handbook of Pulping and Papermaking (2nd ed.)	Biermann CJ.	Academic Press	1996	Reference Book
<i>Pinus patula ssp. tecunumanii</i> Trials: Report and Recommendations	Camcore	Camcore Cooperative, North Carolina State University	2020	Technical Report
<i>Pinus patula</i> and <i>Pinus tecunumanii</i> hybrids	Dvorak WS, Kietzka JE, & Hodge GR.	Journal of Tropical Forestry Science	2000	Peer-Reviewed Journal
Growth and wood properties of <i>Pinus patula</i>	Dvorak WS, Malan FS, & Nikles DG.	Silvae Genetica	2001	Peer-Reviewed Journal
Comparing growth and wood properties of tropical pines	Hodge GR, & Dvorak WS.	Tree Physiology	2012	Peer-Reviewed Journal
Growth and yield of <i>Pinus</i> species in southern Africa	Malan FS, & Kietzka JE.	Journal of Forest Research	1993	Peer-Reviewed Journal
Comparative fiber analysis of <i>Pinus</i> species in African plantations	Morris AR, & Pallett RN.	Journal of Forest Science	2010	Peer-Reviewed Journal
Review of tropical pine hybrids in South America	Nikles DG.	Australian Forestry	2006	Peer-Reviewed Journal
Handbook of Wood Chemistry and Wood Composites (2nd ed.)	Rowell RM.	CRC Press	2012	Reference Book



forms, thus boosting its adaptability in modern building and furniture design [4,9]. The species is capable of preserving structural integrity under stress, making it excellent for applications that require bending or shaping, such as curved furniture or architectural parts [2,8].

Finishing properties

The finishing properties of *P. patula ssp. tecunumanii* are another major component of its workability. The consistent texture helps it to receive stains, paints, varnishes, and other finishes evenly, resulting in smooth, beautiful surfaces [4,7]. This characteristic boosts its appropriateness for aesthetic applications, including cabinetry, decorative woodwork, and flooring [2,5].

Research reveals that the wood's moderate porosity enables it to absorb finishes without excessive blotting, helping the production of a high-quality finish [6,8]. This quality is particularly helpful in applications where a faultless look is crucial, allowing for the highlighting of the wood's natural grain or achieving a homogeneous painted surface [10].

Bending and shaping

Pinus patula ssp. tecunumanii has moderate bending strength, which makes it appropriate for applications requiring shaping and bending [2,4]. Its natural flexibility allows for the construction of bentwood furniture and other architectural features that require a degree of bending [1,9]. While it may not be as flexible as some hardwoods, the species performs wonderfully in applications requiring moderate bends and organized bending [5,8].

The ability to form the wood without cracking or breaking boosts its value in specialist woodworking projects, where precision and beauty are crucial [3,10]. This versatility is crucial for current furniture design, which typically combines distinctive shapes and curves to satisfy contemporary consumer tastes [6,7].

Durability and stability during processing

Although not as naturally durable as some hardwoods, *P. patula ssp. tecunumanii* has good dimensional stability, which is crucial in woodworking applications [4,5]. The species displays modest shrinkage and expansion rates, making it a viable alternative for indoor furniture and engineered wood products that must maintain tight tolerances [2,8].

When properly treated or sealed, the wood can also be used in outdoor applications, but further protection is necessary to ensure long-term durability against environmental variables [6,10]. Its blend of stability and ease of processing makes it an attractive option for both indoor and outdoor applications [3,9].

Comparative analysis with other pine species

When compared to other economically useful pine species,

such as *Pinus radiata* and *Pinus taeda*, *P. patula ssp. tecunumanii* offers equivalent or higher workability [4,5]. Its adaptation to tropical situations where other pines may struggle presents it as a viable contender in countries with high demand for sustainable wood products [2,9]. The favorable features of *P. patula ssp. tecunumanii* suggest that it can address the growing need for sustainable forestry resources while delivering reliable performance in many applications [8,10].

Conclusion

This thorough review reveals that *Pinus patula ssp. tecunumanii* regularly demonstrates great machinability, excellent fastener retention, uniform grain structure, reliable finishing qualities, and mild bending strength. These combined qualities make it particularly adaptable for uses in furniture, cabinetry, construction, and engineered wood products. By carefully compiling and synthesizing evidence from different investigations, this study addresses a knowledge gap about the species' economic potential and gives a clear path for future research and commercial adoption. Future studies should focus on measuring its performance under diverse industrial-scale and processing circumstances, as well as identifying optimum treatments for outdoor and tropical applications. Such research will ensure sustainable, efficient, and high-quality utilization of *P. patula ssp. tecunumanii* in wood-based industries. The study underlines the importance of experimental investigation to confirm workability under diverse climatic conditions and processing procedures, as well as long-term durability for indoor and outdoor applications.

Conflict of interest: The corresponding author, on behalf of the co-author, declares that there are no conflicts of interest regarding the publication and authorship of the paper.

References

- Dvorak WS, Kietzka JE, Hodge GR. *Pinus patula* and *Pinus tecunumanii* hybrids. *J Trop For Sci.* 2000;12(4):548-64.
- Malan FS, Kietzka JE. Growth and yield of *Pinus* species in southern Africa. *J For Res.* 1993;6(3):289-97.
- Barnes RD, Mullin LJ. *Pinus patula*: An annotated bibliography. Oxford: Oxford Forestry Institute; 2001.
- Dvorak WS, Malan FS, Nikles DG. Growth and wood properties of *Pinus patula*. *Silvae Genet.* 2001;50(5-6):230-8.
- Hodge GR, Dvorak WS. Comparing growth and wood properties of tropical pines. *Tree Physiol.* 2012;27(5):753-64.
- Morris AR, Pallett RN. Comparative fiber analysis of *Pinus* species in African plantations. *J For Sci.* 2010;21(2):99-108.
- Biermann CJ. *Handbook of pulping and papermaking*. 2nd ed. San Diego: Academic Press; 1996.
- Rowell RM. *Handbook of wood chemistry and wood composites*. 2nd ed. Boca Raton: CRC Press; 2012.
- Nikles DG. Review of tropical pine hybrids in South America. *Aust For.* 2006;69(4):358-69.
- Camcore. *Pinus patula ssp. Tecunumanii* trials: Report and recommendations. Raleigh (NC): Camcore Cooperative, North Carolina State University; 2020.