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Comparative Review of Wood and Non-Wood Fibers for Paper Production and Their Bleaching Requirements

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Abstract

The increasing global demand for sustainable, high-quality paper has renewed interest in evaluating both wood and non-wood fibers as viable raw materials for pulp and paper production. This comparative review examines the anatomical, chemical, and mechanical properties of wood (softwood and hardwood) fibers in contrast with commonly used non-wood fibers such as bagasse, bamboo, jute, kenaf, wheat straw, rice straw, and hemp. Literature indicates that wood fibers, particularly softwoods, provide long and strong fibers ideal for tensile strength and durability, whereas hardwoods supply shorter fibers that enhance paper smoothness and opacity. Non-wood fibers, on the other hand, offer advantages such as rapid renewability, lower lignin content, and availability in regions facing forest resource constraints. Their heterogeneous structure, high hemicellulose content, and variable fiber morphology, however, pose challenges in pulping and bleaching processes.

The review highlights significant differences in bleaching requirements between wood and non-wood fibers. Wood-based pulps typically require conventional chemical bleaching sequences (ECF—Elemental Chlorine Free, and TCF—Totally Chlorine Free), relying heavily on chlorine dioxide, oxygen, hydrogen peroxide, or ozone to remove higher lignin content and achieve brightness targets. In contrast, non-wood fibers such as bagasse and agricultural residues generally exhibit lower lignin levels and respond effectively to milder bleaching agents, including alkaline hydrogen peroxide, oxygen delignification, and enzymatic pre-bleaching. Nevertheless, non-wood fibers often contain higher levels of silica and extractives, leading to operational difficulties such as scaling, equipment wear, and chemical inefficiencies during the bleaching sequence.

Environmental implications are also central to this comparative assessment. Wood fiber bleaching traditionally generates higher levels of chlorinated organic compounds, necessitating advanced effluent treatment systems. Non-wood bleaching tends to be more environmentally favorable due to lower chemical consumption, although waste management of agricultural residues remains a concern. Recent advances in biotechnology—such as the use of xylanase, laccase, and lignin-modifying enzymes—have shown promising potential in reducing chemical loads and improving brightness in both fiber categories.

Overall, the review concludes that while wood fibers remain the backbone of global papermaking due to their uniform quality and superior mechanical properties, non-wood fibers provide a sustainable and regionally adaptable alternative with evolving technological viability. Optimizing pulping and bleaching methods according to the unique characteristics of each fiber type is essential for enhancing paper quality, reducing environmental impact, and supporting the transition toward sustainable, eco-efficient paper manufacturing. Future research should focus on hybrid fiber blends, integrated biobleaching processes, and low-impact bleaching technologies to meet the growing demand for environmentally responsible paper products.