Beyond wood – structural and functional diversity in lignified tissues

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ABSTRACT

Wood, i.e., secondary xylem derived from a bifacial cambium is widespread among plants. However, various types of lignified cells and tissues can be found and are often connected to specific functions, three examples of which will be presented.

Flagellaria is a climbing monocot with a unique stem anatomy and biomechanical properties that attaches to the surrounding vegetation via leaf tendrils. Biomechanical methods such as three-point bending and torsion tests were used together with anatomical studies on tissue development, modification and distribution. Mechanical properties were modulated via tissue differentiation processes mainly affecting the cortex of the stem. Although F. indica lacks secondary cambial growth, the climbing habit is facilitated by a complex interaction of tissue maturation and attachment.

Apple (Malus) fruit peduncles are highly modified stems that connect growing fruits securely to the branch while the weight, i.e., static and dynamic loads increase. We studied the tissue formation and modification during fruit development in peduncles, in which fibers contribute mainly to tensile strength and overall axial rigidity of the peduncles while sclereids effectively increase bending stiffness.

Some Martyniaceae produce lignified capsules with hook-shaped extensions that attach to feet of large mammals. The arrangement of fibers in the fruit wall is unique among plants that we studied anatomically and mechanically under different load conditions. At the cell wall level, both a large microfibril angle and greater strain rates resulted in moderate Young's moduli of 4-9 GPa, and high tolerance against large deformations under various load conditions. Longitudinally arranged fiber bundles contribute to a great tensile strength. At the tissue level, transversely oriented fibers absorb radial stresses upon bending and stabilize longitudinal bundles against buckling. While the increased flexibility allows for proper attachment of fruits during dynamical locomotion, the high strength and stability prevent a abrupt failure due to heavy loads exerted by the animal.