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A study on wood anatomy of a few tree species in Western Himalaya

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A B S T R A C T

Wood anatomy of 10 tree species of Western Himalaya of which 4 species belong to Fagaceae (*Quercus incana, Quercus lanata, Quercus floribunda, and Castanopsis indica*), 1 species belongs to family Ericaceae *(Rhododendron arboreum),* 1 species belongs to Platanaceae *(Platanus orientalis*), 1 is under Betulaceae (*Betula utilis*), the other 1 is under Salicaceae (*Populus deltoides*) and the other 2 species belong to Proteaceae and Lauraceae (*Grevillea robusta* and *Lindera pulcherrima*) were investigated with their different anatomical features. Transverse Section (T.S), Tangential Longitudinal Section (T.L.S) and Radial Longitudinal Section (R.L.S) were prepared for microscopic studies. Characteristic similarities and disparities in the tissues arrangement as well as cell inclusions were noted for description and delimitation. Characters of tracheary elements, in particular, the tracheid and vessel*;* fibre and ray parenchyma structure are studied among these species. The ray cells are strictly uniseriate in the woods *of Quercus incana, Quercus lanata, Quercus floribunda, Betula utilis* and *Populus deltoides,* biseriarte in *Castanopsis indica, Rhododendron arboreum, Lindera pulcherrima* and strictly multiseriate in the woods of *Grevillea robusta* and *Platanus orientalis.* The presence of a least amount of ray cells is a good quality of timber. It is also considered as an advanced anatomical feature. The objective of the research is to study the wood anatomy of some tree species in Western Himalaya and its significance in dendrology and application.

Keywords: Wood anatomy · Forest · Tracheary elements · Woody species · Western Himalaya

1. Introduction

Human beings are depending on the plants for food, shelter and medicine. Besides this, wood has considerable importance in the livelihood of ancient people in making several things such as agricultural implements, paper, boat building, handicrafts, packing cages, toys, furniture, building construction *etc*. The wood that is considered as most important forest product till date has contributed a lot to advancement of civilization. Though the forests are vanishing at an alarming rate, the requirement of the wood has not declined. The wood anatomists are concerned with wood quality and interested first of all, in general, in structural features of the particular species which determine their properties, ascertain their uses and applications. Cell size, proportion and arrangement of the various types of elements and tissues, for example, tracheid, vessels, fibres, parenchyma, and of early wood and late wood, determine the grain and figure. Cell diameter in relation to thickness of the cell wall and the proportion of their thick walled cells determine density which is closely related to mechanical strength and working properties, and yields in pulping. Scientific diagnosis of wood structure requires very profound knowledge.

In forestry and forest based industries, wood quality is a topic of concern for the concept of short plant rotation and intensive managed plantation for the sake of forest management [1,2]. A good number of studies were carried out all over the world on wood properties [3-14]. In a particular species or clone the wood quality may vary with the change in climate and environment. Wooden skeleton of a tree gains mechanical power through fibres for hard woods and tracheids as properties for soft woods. Properties of cell walls provide rigidity in wood and are considered as mechanical properties of wood. Fibres in highest quantity make the wood stronger and become able to withstand the loads of tree organs and effects of wind. Stiffness of wood that is the contribution of the ratio of cell wall materials, thickness and properties of cell lumen etc. makes the tree resistant from bending [15]. The objective of the research is to study the wood anatomy of some tree species in Western Himalaya and its significance in dendrology and application.

2. Materials and Methods

Methodology is a way to solve research problems systematically. It may be understood as the science of studying how research is done scientifically. In it we study the various steps that are generally adopted by a researcher in studying his or her research problems along with the logic behind them.

The study is mainly based on the collection of the plants from Western Himalayan region in India. The plants which were studied in the taxonomic work were collected from the sampling area. Specimens as flowering twig and secondary wood portions were collected. *Lindera pulcherima, Castanopsis indica* and *Betula utilis* were collected from Munsiyari, *Platanus orientalis*, *Quercus incana, Quercus floribunda* and the tree *Populus deltoides* were from Nainital, *Rhododendron arboreum* from Mukteshwar, *Grevillea robusta* and *Quercus lanata* collected from Almora. The tree samples were collected in a systematic way and preserved methodically. Transverse Section (T.S), Tangential Longitudinal Section (T.L.S), and Radial Longitudinal Section (R.L.S) were done from the collected wood materials. The sections were stained with safranin and light-green and observed through microscope.

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Permanent slides were prepared for future identification. After thorough study of the specimen diagrams, detailed descriptions were made. In total, there was a collection of about 10 different species belonging to different or same families.

3. Results and Discussion

Wood properties and characteristics may have influence by variation in wood anatomy [16-18]. During cell division, the monolayer cambium of vascular system constructs wood but a group of cells take part with different functions to become as a tree in general. The combination of different cells with their collection of different matters with time interval produces growth rings. A variation in composition and distribution, pits and orientation of different cell types and growth increments lead to diversification in wood character.

Tree specimens collected from family Proteaceae, Fagaceae, Platanaceae, Ericaceae and Salicaceae show ring porous or semi-ring porous wood in trees like *Grevillea robusta, Quercus incana, Quercus lanata, Quercus floribunda, Castanopsis indica, Platanus orientalis, Rhododendron arboreum, Populus deltoides* is considered to be a little more advanced than (Table 1) wood exhibiting diffuse porous in *Lindera pulcherrima* and *Betula utilis.* Apotracheal diffuse parenchyma exhibits more primitive wood in trees like *Betula utilis*, *Platanus orientalis, Quercus incana, Quercus lanata, Quercus floribunda*, *Castanopsis indica, Rhododendron arboreum, Populus deltoides,* and *Castanopsis indica.*

Woods having heterogeneous types of ray are considered primitive in trees like *Rhododendron arboreum, Lindera pulcherrima.* The advanced form of ray is either uniseriate or multiseriate with procumbent cells (homogeneous) found in trees like *Populus deltoides, Grevillea robusta, Castanopsis indica, Quercus incana, Quercus lanata, Quercus floribunda, Betula utilis, Platanus orientalis* (Table 1).

Vessel is arisen from no other cell than tracheid that is long and narrow spindle shaped. So it is assumed that long vessels are primitive in trees like *Castanopsis indica, Grevillea robusta, Quercus incana, Quercus lanata, Quercus floribunda.* The advanced form is short and wide in trees like *Betula utilis, Platanus orientalis, Rhododendron arboreum, Populus deltoids, Lindera pulcherrima.*

Vessel with scalariform pitting is most primitive. Evolutionary sequence advanced through transition types to opposite type in trees like *Platanus orientalis, Quercus incana, Quercus lanata, Quercus floribunda, Rhododendron arboreum.* The final stage of evolution is alternate pitting in trees like *Betula utilis, Castanopsis indica, Grevillea robusta, Lindera pulcherrima, Populus deltoides.* Comparison between tree species is represented in Table 2.

Table 1 Comparison between the woods of the following tree species showing primitive and advanced characters as per Dickinson, (1997) [19]

Characters	Name of the tree species			
	Lindera pulcherrima (Lauraceae)	*Platanus orientalis* (Platanaceae)	*Populus deltoides* (Salicaceae)	*Betula utilis* (Betulaceae)
Porosity of wood	Diffuse porous (P)[#]	Semi-ring porous (A)	Semi-ring porous (A)	Diffuse porous (P)
Axial parenchyma	Paratracheal (A) *	Apotracheal (P)	Apotracheal (P)	Apotracheal (P)
Ray cells	Heterogeneous (P)	Homogeneous (A)	Homogeneous (A)	Homogeneous (A)
Pitting type	Alternate (A)	Opposite (P)	Alternate (A)	Alternate (A)
Vessel size	Small 48.5 µm - 86.25µm (A)	Small, 56.25µm - 84.70 µm (A)	Small, 52.5µm - 71,74µm (A)	Small, 67.5µm - 93.75µm (A)
Occurrence of vessel	Solitary(P)	Solitary(P)	Solitary(P)	Solitary(P)
Amount of lignification	Less Lignification, 1.2µm(P)	Less Lignification, 1.27 µm(P)	Less Lignification, 1.35µm(P)	Lignifled, 3.1µm (A)
Durability	Nondurable (P)	Nondurable (P)	Nondurable (P)	Durable (A)

*(A) Advanced [#](P) Primitive

In the transverse section of wood it is observed that the vessel may be present in solitary or in group. Solitary vessel represents primitive condition, for example, *Platanus orientalis, Betula utilis, Quercus incana, Quercus lanata, Quercus floribunda., Castanopsis indica, Linderd pulcherrima, Populus deltoides* and *Rhododendron arboreum*. During specialization the vessels are arranged in group in tree like *Grevillea robusta*.

Table 1 (*Continued*)

Characters	Name of the tree species			
	Quercus Incana, Quercus lanata, Quercus floribunda (Fagaceae)	*Castanopsis indica* (Fagaceae)	*Grevillea robusta* (Proteaceae)	*Rhododendron arboreum* (Ericaceae)
Porosity of wood	Ring porous (A) *	Ring porous (A)	Ring porous (A)	Semi-ring porous (A)
Axial parenchyma	Apotracheal (P) #	Apotracheal (P)	Paratracheal (A)	Apotracheal (P)
Ray cells	Homogeneous (A)	Homogeneous (A)	Homogeneous (A)	Heterogeneous (P)
Pitting type	Opposite (P)	Alternate (A)	Alternate (A)	Opposite (P)
Vessel size	Large,43.73 µm- 108.75µm, 40.75 µm - 144.80µm, 40.00µm - 138.5µm (P)	Large, 53.25µm-149.62 µm (P)	Large, 48.75µm - 152.5µm (P)	Small, 53.8µm -91.82µm (A)
Occurrence of vessel	Solitary(P)	Solitary(P)	Group (A)	Solitary(P)
Amount of lignification	Lignified, 3.12µm (A)	Lignified,3,41µm (A)	Lignified, 4.1µm (A)	Lignified, 3.9µm(A)
Durability	Durable (A)	Durable (A)	Durable (A)	Durable (A)

*(A) Advanced #(P) Primitive

Table 2 Comparison between the woods of the following tree species showing primitive and advanced characters based on (Dickinson WC 1997)[19]

Name of Trees	Number of Characters	
	Primitive Characters	Advanced Characters
Lindera pulcherrima	5	3
Platanus orientalis	5	3
Populus deltoides	4	4
Betula utills	3	5
Quercus incona, Quercus lanata, Quercus floribunda	4	4
Castanopsis indica	3	5
Grevillea robusta	1	7
Rhododendron arboreum	4	4

Lindera pulcherrima and *Rhododendron arboreum* showed heterogenous ray cells whereas homogenous ray cells found in *Platanus orientalis, Populus deltoides, Betula utilis, Quercus incana, Quercus lanata, Quercus floribunda, Castanopsis indica and Grevillea robusta*. Alternate pitting found in trees like *Lindera pulcherrima, Populus deltoides, Betula utilis, Castanopsis indica and Grevillea robusta* whereas opposite pitting found in trees like *Platanus orientalis, Quercus incana, Quercus lanata, Quercus floribunda* and *Rhododendron arboreum.*

Based upon the vessel size, shape and thickening, the wood is considered to be more durable and resistant. Wood obtain from *Grevillea robusta*, *Quercus incana, Quercus lanata, Quercus floribunda, Castanopsis indica, Rhododendron arboreum, Betula utilis,* is considered to be advanced whereas *Lindera pulcherrima, Platanus orientalis, Populus deltoides,* are considered to be primitive as they possess soft wood.

Wood properties are basically influenced by diverse anatomical characters. Anatomical characteristics of wood are provided with cell distribution, properties, sizes etc. The wood elements and composites may vary not only in species range, but also in a single tree [20-24]. Authenticity and genuinity of the wood can be identified with the help of wood anatomical features, which also helps to differentiate good quality wood from adulterated wood for

example, such trees as *Lindera pulcherrima, Platanus orientalis*, *Populus deltoides*, indicate their low quality of wood with less lignification, are used mainly for paper making, handcrafts, furniture making and inferior finish of houses etc., whereas *Rhododendron arboreum*, *Betula utilis, Quercus incana, Quercus lanata, Quercus floribunda, Grevillea robusta* and *Castanopsis indica* indicate their high and good quality of wood. The wood of these trees is used for making wooden articles, agricultural implements, musical instruments, turnery, boat building etc. as it possesses more lignified woody elements. The wood of these trees is used for making wooden articles, agricultural implements, musical instruments, boat building etc. as it possesses more lignified woody elements.

4. Conclusion

All the specimens consist of both more or less primitive and advanced features, but among them*, Grevillea robusta, Castanopsis, Quercus incana, Quercus lanata, Quercus floribunda, Rhododendron arboreum and Betula utilis* possess more advanced characters than *Lindera pulcherrima, Platanus orientalis* and *Populus deltoides.* The *Lindera pulcherrima* has poor quality of wood and the wood of *Platanus orientalis and Populus deltoides* contains more pores and they are non-durable. Their wood quality is of inferior type. The study revealed that the wood of *Rhododendron arboreum* and *Betula utilis* is finely grained. Heartwood which light to medium brown with rays makes the wood of *Grevillea robusta* strong. The wood of *Quercus incana, Quercus lanata, Quercus floribunda* and *Castanopsis indica* is strongly grained and durable. So, the wood of such trees is long lasting and used for wooden buildings and also for agricultural purposes etc. The present study also revealed profound structural diversity in wood anatomy and also has significant correlation with utility and quality of wood among ten species of woody trees in the Western Himalayan region.

Conflict of interest

The author declares that there is no conflict of interest in this manuscript.

Data availability

The author confirms that all data collected or analyzed during this study are included in this published article.

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