한국가구학회지 2010.01. Vol. 21(1): 54-61

Comparison of Some Anatomical Characteristics between Eunsasi Poplar and Konara Oak[1]

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ABSTRACT

This study was carried out to identify the differences of some macro and micro-anatomical features between Eunsasi poplar (*Populus tomentiglandulosa* T. Lee) and Konara oak (*Quercus serrata* Thunb.). Anatomical features such as vessel and fiber diameter, cross sectional area of ray parenchyma and endwall pit aperture diameter in ray parenchyma were compared. Differences of anatomical features between two species were found statistically significant. Earlywood vessel diameter in poplar and oak increased from pith to bark while it was found almost stable in latewood. Fiber diameter in poplar was higher than oak fiber. Ray area and the pit aperture diameter in endwall of ray parenchyma were found higher in oak than those in poplar.

Keywords: Anatomical features, hardwood, vessel and fiber diameter, endwall pit of ray parenchyma.

1. INTRODUCTION

The permeability of wood has been intensively studied because of its importance to wood processing (Erickson 1970; Siau 1970; Choong et al. 1972), and also because the methods of measuring permeability differ considerably (Resch and Ecklund 1964; Siau 1971). Despite large amount of work on permeability, only a few limited studies have been made to identify

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1. 논문접수: 2009. 09. 07.; 심사: 2009. 10. 02.; 게재확정: 2010. 01. 16. 'This work was supported by the Korea Research Foundation Grant funded by the Korean Government. (MOEHRD)' (KRF 2009 361 G00013) and Institute of Environmental Research at Kangwon National University.
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the variation of liquid permeability related to wood anatomical features (Choong and Tesoro 1974, Stamm and Raleigh 1967; Kininmonth 1971) and comparative permeability among various species (Bao et al. 1999; Choong et al. 1972).

The permeability in wood varied considerably among species or even in the same species in different parts (Bao 1984). There are many factors such as pore size, anatomical features, moisture content, specimen length etc. which influence the permeability in wood (Nicholas and Siau 1973). Generally, the sapwood has higher permeability than heartwood. Also there are striking differences between ring porous wood and diffuse porous wood. Diffuse porous wood has higher permeability than ring porous wood (Bao et al. 1999).

It is very evident that the annual ring of Eunsasi poplar is seldom clear and vessel arrangement is diffusely porous with dark grayish brown heartwood and light brown sapwood. There is no distinguishable color to separate intermediate wood. As it's air-dry specific gravity is 0.42 and the strength is not too high, drying and processing are easier and plywood products manufacturing (Chong and Park 2008). So, it is believed that this kind of species can be used as internal material for making furnitures. On the other hand, Konara oak is ring porous wood, annual ring is very clear and the difference of earlywood and latewood vessel is very vivid. The air-dry specific gravity of this species is 0.78 and is more valuable than wood processing and plywood manufacturing (Chong and Park 2008). As a result, this species can be used for surface wood materials for furnitures.

Therefore, it is curious to know what kind of anatomical differences exist between ring and diffuse porous wood which could affect the liquid permeability. To do so, ring porous wood and diffuse porous woods have been selected to conduct this study. The aim of this study was to determine the extent of the anatomical elements and the wood structure which differ from diffuse porous wood, Eunsasi poplar to the ring porous wood, Konara oak. The differences were observed from pith to bark and were analyzed to find whether there were significant differences between those species. This work is a part of the study which aims to have a better comprehension of the structural differences which apparently control the lateral and longitudinal liquid conduction.

2. MATERIALS AND METHODS

Sample collection

This study was carried out in 15 year old Eunsasi poplar (*Populus tomentiglandulosa* T. Lee) and 20 year old Konara oak (*Quercus serrata* Thunb.). Wood discs were collected from non leaning and defect free trees from Jiamri, Sabukmeyon, Chunchon, Kangwon do, Republic of Korea. Discs were made from freshly cut logs at 1.2 m above the ground level and the wood disc of 5 cm long with the bark intact were made.

Micro structural measurement

Each micro-structural feature was measured from pith to bark. From the wood disc, several sample stipes were made from pith to bark with visible growth rings in cross section. Tangential and cross sectional blocks were made from the sample stripes and were finished with a microtome. The clean-cut surface was (3 mm x 3 mm) cut into 1 mm thickness. After vacuum drying, blocks were adhered to aluminum stubs with double sided tape and coated with platinum (Pt) by using an ion sputter apparatus (HITACHI E 1010). At different resolutions and magnifications, the samples were examined at accelerating voltage of 5 kV in a Hitachi S 4300 FESEM (Field Emission Scanning Electron Microscope). The anatomical features which were measured include vessel and fiber diameter, ray lumen area and the pit aperture diameter of endwall (tangential wall) pits in ray parenchyma. Features for every growth ring were measured for 30 times.

Statistical analysis

Two sample analysis of variance (at alpha= 0.05 or 95% confidence level) were used to identify significant differences of different anatomical features between two species (SPSS, Version 12.0.1, 2003).

3. RESULTS AND DISCUSSION

Vessel size is related to permeability because it is the principal flow path for fluids in hardwoods. Wood permeability is especially an important property for treatment with liquid, for example, preservatives for protection against decay. It also affects the ease of diffusion of water to or from the wood during the drying process or, while in use, in response to changes in air relative humidity (Siau 1995).

Figure 1 shows the radial variation of vessels from pith to bark in poplar and oak. Tangential diameter increased from pith to bark. Ring porous wood such as oak, the vessel diameter in earlywood was found in increasing trend from pith to bark. On the contrary for diffuse porous wood such as poplar the trend was almost stable towards the bark. Similar radial trend in earlywood vessel diameter of oak was also reported by Voulgaridis (1990), Lei et al. (1996) and Tsuchiya and Furukawa (2009). The same trends but in minor extent were observed in the case of vessel member diameter of latewood. Average diameter of latewood vessel in oak was 2.1 times smaller than that in poplar. But large vessel of oak was 2.2 times wider than earlywood vessel in poplar and those differences were found statistically significant at P=0.000.

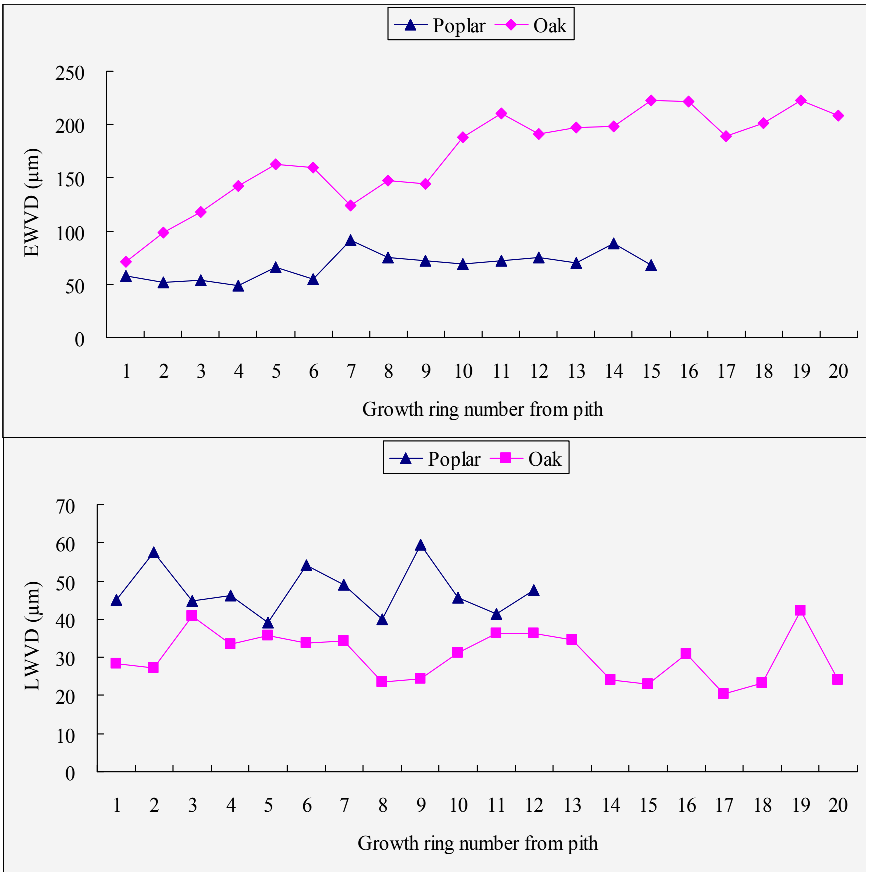

Fig. 1. Variation of mean tangential vessel diameter between poplar and oak. EWVD: Earlywood vessel diameter, LWVD: Latewood vessel diameter.

Although fiber often constitutes the majority of woody tissue, general fiber is not considered as important as vessels in primary liquid flow (Leal et al. 2007). Fiber has non perforated end. Even though fiber structure does not facilitate the easy penetration of liquid, some times it conducted more liquids than vessels (Thomas 1976). Although fibers often constitute the bulk of woody tissues, in general they are not considered to be as important as vessels in initial liquid penetration. However, their permeability may have a decided influence on the subsequent spread of liquid from vessels. Compared to vessels, non-perforated fibers are thick walled and have relatively small pits that are not adapted for efficient liquid conduction. The radial trends for fiber lumen diameter for poplar and oak were shown in Figure 2. Fiber diameter of poplar increased from the pith, reached the maximum size in the middle wood and then remained fairly constant towards the bark. Contrarily, the lumen diameter of fiber in oak showed a decreasing trend from pith to bark.

But the declination of fiber lumen diameter was found small. On an average, fiber lumen diameter in poplar was found 2.5 times significantly higher than that of oak.

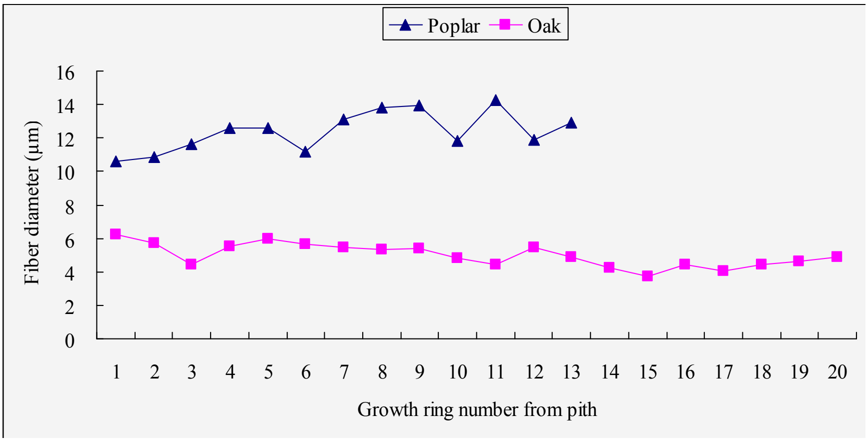

Fig. 2. Variation of mean tangential fiber diameter between poplar and oak.

The ray parenchyma of wood is specialized for the seasonal storage and mobilization of organic and inorganic material (Sauter 1982; Braun 1970). Moreover, only a small fraction of the tangential cell walls are found to be occupied by prominent pits while the remainder of the cell wall is heavily thickened and lignified (Sauter and Kloth 1986). Since the bulk flow of liquid material in the ray cells most evidently goes via these pit fields and thus the ray play an important role in liquid penetration. Studies have suggested that rays act as important flow paths for liquids during impregnation (Wardrop and Davies 1961; Banks 1970). The flow depth of liquid through ray cells will be higher in cells with narrow lumen diameter than those cells with wider lumen. Also, pits have a large impact on the structural resistance for liquid flow (Schulte and Gibson 1988). In this experiment we found that the cross sectional area of ray parenchyma was wider in oak compared with poplar. In poplar and oak, area of ray parenchyma was found the highest near the pith region and decreased gradually up to 3 growth rings and was stable towards the bark (Fig. 3). Different result was reported by Rahman et al. (2005) where teak was used for measuring the ray width.

As the ray parenchyma of poplar was narrower than that of oak, it can be expected that the ray parenchyma in poplar will be more permeable than that in oak. But ray cell length, pit number and diameter in tangential wall (endwall) of ray parenchyma should also be considered. The average number of endwall pits in ray parenchyma was found 12 for poplar and oak. But the pit aperture diameter in endwall of ray parenchyma was found significantly higher in oak than that in poplar. In both species, the pit aperture diameter in endwall of ray parenchyma was found higher near the pith and was stable toward the bark (Fig. 4).

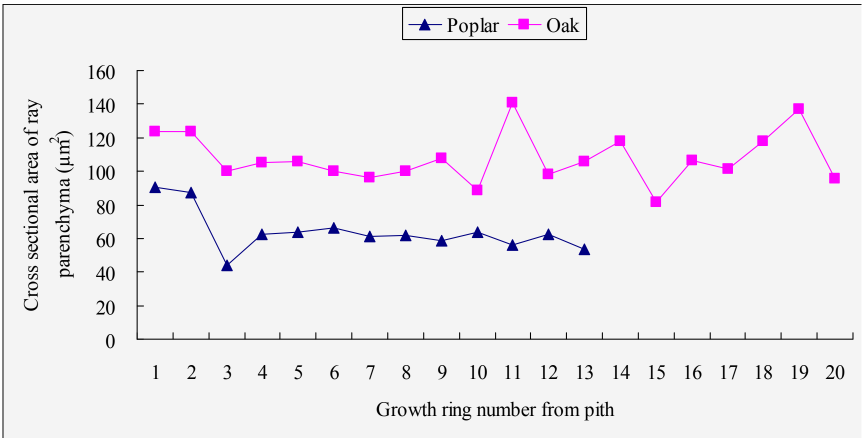

Fig. 3. Variation of cross sectional area of ray parenchyma between poplar and oak.

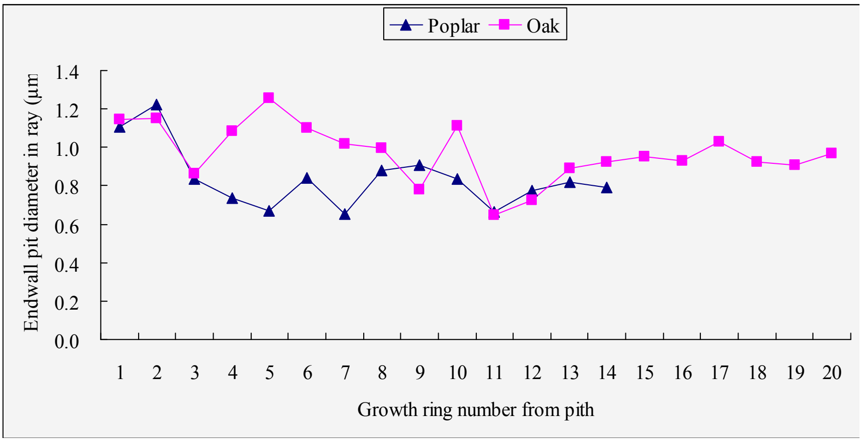

Fig. 4. Variation of endwall pit aperture diameter of ray parenchyma between poplar and oak.

In this experiment no permeability test has been conducted. As it is well known that different factors are responsible for liquid permeability in wood like species, anatomical characteristics, liquid properties etc. Among them anatomical factors is the most important factor for which variation of liquid permeability observed between species to species (Thomas 1976). The anatomical features mentioned in this paper will be helpful to understand the reasons of permeability differences between two wood species.

4. SUMMARY

The anatomical variations between the two hardwood species were revealed. Vessel diameter, fiber diameter, cross sectional area of ray parenchyma and endwall pit aperture diameter in ray parenchyma were found significantly different. The anatomical characteristics showed variations between the two hardwood species taken under consideration. Earlywood vessels diameter of both poplar and oak had increasing trend from pith to bark while in latewood it was almost stable from early growth stage to the maturation. Fiber diameter was found higher in poplar than in oak and it was in increasing trend from pith to bark. In oak, fiber diameter was declined little from pith to bark. Area of ray parenchyma and endwall pit aperture diameter in ray parenchyma was found higher in oak than poplar.

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