Safranine Penetration Observed by Optical Microscope in Main Wood Species of Pinaceae Grown in Korea

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Introduction

The mechanism of liquid flow in wood plays an important role for the processing of wood which is related with wood preservation treatment, fire retardant treatment, dimensional stability or wood drying. Anatomical characteristics of wood especially capillary structures of wood are important factors to determine the liquid penetration in wood (Park et al. 1987). All wood species posses a capillary structure and its effect in fluid permeability varies considerably (Bao et al. 1999). Capillary structures are very important to determine the liquid penetration. Main capillary structures consist of tracheids in softwood also ray cell, resin canal and pit membrane play an important role in liquid penetration of wood (Kim and Park 1991). The present investigation was taken under consideration to find out the reason behind for the variation of permeability of safranine in Korean pine wood using optical microscope.

Materials and Methods

Wood species used

Four kinds of wood block were taken under consideration from ① *Pinus koraiensis* Sieb. et Zucc. ② *Pinus densiflora* Sieb. et Zucc. ③ *Pinus rigida* Mill and ④ *Larix kaempferi* Carr. Wood samples were collected from Kangwon National University reserve forest at breast height. Immediately after collection, discs were made and kept in air tight cellophane bag to protect the moisture loss. 6 x 0.5 x 1cm samples were prepared for collected discsby separating sap and heartwood. For radial direction penetration, both cross sections were sealed with silicon resin for preventing the leakage by longitudinal penetration. Samples were soaked in safranine for 5 minutes. After inputting the safranine in different wood, permanent slides were prepared using microtome and were observed under optical microscope to findout the cells responsible for safranine impregnation in both sap and heartwood. 25 counting were done to findout the mean number of ray parenchyma, ray tracheid, resin canal and pit numbers. Finally data were analyzed by statistical analysis software, SPSS (George and

Mallery 2001).

<Table 1> General habit of sample disc observed by naked eye.

Features	*P. densiflora*	*P. rigida*	*P. koraiensis*	*L. kaempferi*
Number of annual rings (Number)	27	26	35	18
Range of juvenile wood (years from pith)	1~17	1~14	1~19	1~14
Range of matured wood (years from pith)	18~27	15~26	20~35	15~18
Range of heartwood (years from pith)	1~6	1~6	1~22	1~13
Range of sapwood (years from pith)	7~27	7~26	23~35	14~18

Estimation of moisture content (%)

Wood block was weighed and dried in an oven for 24 hours maintaining the temperature 105 OC. Moisture content of wood block in terms of dry weight basis was calculated using the following formula (Skaar 1972):

$$M\ (\%) = \frac{W_m - W_O}{W_m} \times 100$$

M = Moisture content

W_m= Moist weight of wood

W_O= Oven dry weight

Result and discussion

By optical microscope number of resin canal, ray parenchyma, ray tracheid and pits present in endwall pit were counted. It was shown below-

<Table 2> Number of ray parenchyma, ray tracheid and resin canal in different wood species observed under optical microscope.

Wood species		*P. koraiensis*	*P. densiflora*	*P. rigida*	*L. kaempferi*
Ray parenchyma (range)		5NS (1~12)	4NS (1~7)	3NS (1~6)	4NS (1~9)
Ray tracheids		2b	3ab	4a	2b
Early wood (endwall pit)	Pit/Ray parenchyma	1b	1b	1b	3a
	Pit /Ray tracheids	2 b	3a	3a	2ab
Late wood (endwall pit)	Pit/Ray parenchyma	1b	1b	1b	3a
	Pit/Ray tracheids	2b	3a	3a	2ab
Early wood	Resin canal	8a	6a	2b	3b
Late wood	Resin canal	2b	3ab	3b	5a

Mean with the same letter are not significantly different at p=0.05

NS: Non significant at 5% level of probability

It was found that *P. koraiensis* contained the highest number of ray parenchyma in ray structure and *P. rigida* contained the highest number of ray tracheids. *L. kaempferi* contained the highest number of pits in the endwall of ray parenchyma and ray tracheids of earlywood. Counting of endwall pit is important because it is one of the factors which are related with transverse conduction of safranine. Resin canal also conducts liquid in longitudinal direction. *P. koraiensis* and *L. kaempferi* contained the highest number of resin canal in earlywood and latewood respectively. From optical microscope it was observed that *L. kaempferi* has the highest number of endwall pits in ray parenchyma and ray tracheid.

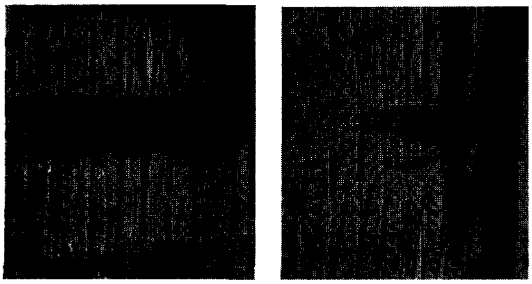
Moisture content

Moisture content plays an important role for the impregnation of liquid in wood block. Above the fiber saturation point, wood can still take up water by absorption or capillary action until the cell cavity are filled with liquid water (Browning 1963). The permeability of some wood species decreases with increased moisture content (Comstock 1968). Excess moisture in wood voids may also act as a physical barrier for the mass flow of liquid (Wirspa and Libby 1950).

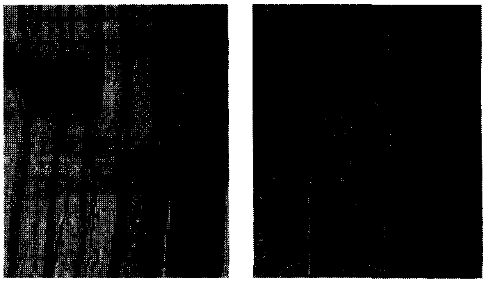
〈**Table 3**〉 Average moisture content (mean±SE) in different wood species.

Wood species	Moisture content (%)
P. koraiensis	6.9±0.36
P. densiflora	9.0±0.63
P. rigida	6.9±0.28
L. kaempferi	6.0±0.45

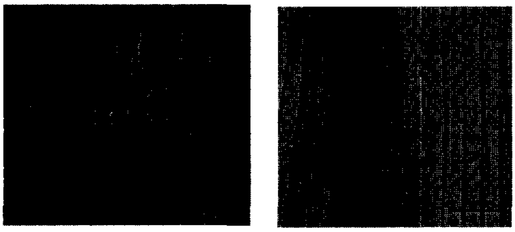
All wood species possess a capillary structure and its effect on fluid permeability varied considerably. Wood is a capillary porous medium. The pore structure is defined by the cell lumen and the cell wall openings (pits) which interconnect them. If the pit membrane opening are large and numerous, the permeability is higher (Comstock 1967). The primary routes for liquid penetration into wood are provided by these capillaries (Smith and Banks 1971, Wardrop and Davis 1961 and Bailey 1913). Tracheid length and diameter are also important factors for longitudinal penetration. Following is the table showing data about the longitudinal tracheid length and diameter.



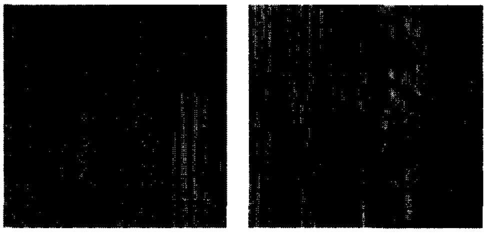
⟨Fig. 1⟩ In radial direction, safranine penetration in sapwood (left) and heartwood (right) of *P. rigida.*



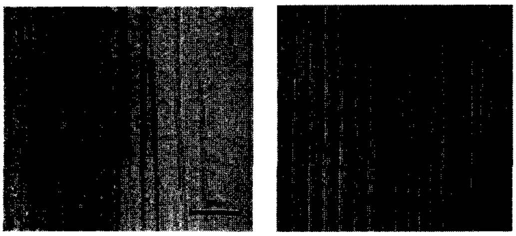
⟨Fig. 2⟩ In radial direction, safranine penetration in sapwood (left) and heartwood (right) of *L. kaempferi.*



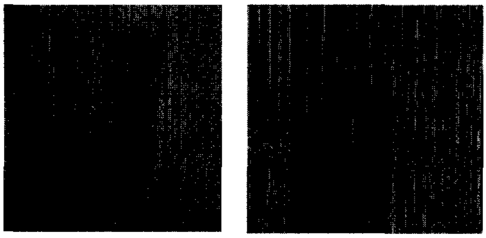
⟨Fig. 3⟩ In longitudinal direction, sap latewood and resin canal in heartwood (right) conduction of safranine in *P. koraiensis.*



⟨Fig. 4⟩ In longitudinal direction, sap early and latewood (left) conduction of safranine and tylosoid (right) in *P. densiflora* heartwood.



⟨Fig. 5⟩ In longitudinal direction, sap earlywood (left) and latewood (right) conduction of safranine in *P. rigida.*



⟨Fig. 6⟩ In radial direction, earlywood (left) and latewood (right) safranine conduction in *P. densiflora* heartwood.

Heartwood treatability was found poor. Ray tracheid conductivity was low in heartwood of all wood species (Fig 1 and 2). For this reason, heartwood safranine penetration was found lower than sapwood. Vertical Resin duct also conducted safranine in longitudinal direction (Fig. 3). It is clear that safranine was diffused from ray parenchyma to longitudinal tracheid through cross field pitting. Tylosoid present in heart wood couldn't able to conduct safranine (Fig. 4). From longitudinal tracheid safranine was diffused to ray parenchyma through cross field pitting (Fig. 5). In longitudinal penetration it was found that latewood penetration is faster than earlywood penetration (Fig. 5 and 6). This phenomenon can be resulted from capillary action. From vertical resin duct safranine was diffused to longitudinal tracheid (Fig. 3). The pathway can be explained like safranine in resin canal moved to the neighboring tracheid through pits and then through the cross field pitting it passed to ray cells and then moving along for a distance it entered longitudinal tracheid through cross field pitting and so on.

Conclusion

From camscope observation it was found that *P. koraiensis* contained the highest number of ray parenchyma and ray tracheid in ray structure. Ray parenchyma and ray tracheid in sapwood played an important role for the penetration of safranine in radial direction. But heartwood tracheid was found low permeable compared with ray parenchyma. Early and latewood penetration in longitudinal direction was not found same. Latewood conduction was observed higher than the earlywood both in sap and heartwood. Tylosoid was found impermeable. Resin canal diffused safranine faster than longitudinal tracheid. Number of resin canal was found highest in *P. koraiensis* and p. rigida had the lowest. In longitudinal direction, the path of safranine impregnation was found that it diffused from longitudinal tracheid to ray parenchyma through cross field pitting and from longitudinal resin canal to ray parenchyma or longitudinal tracheid. Furthermore it diffused from longitudinal tracheid to its neighboring tracheid through bordered pit or ray parenchyma through cross field pitting.

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