Permeability studies show that California white oak containers will hold wine during wine aging with a minimum loss from seepage and evaporation. Effects of this wood on quality were not evaluated.

California oak tanks for California wine

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Use of California white oak (*Quercus lobata*) for tight cooperage has been considered for many years, particularly by the whiskey industry in the eastern United States, because of increasing shortages of suitable eastern oaks. Investigations were not pursued, because the reported volume of timber available was quite small. However, a substantial volume does exist, although an accurate inventory has never been made. California white oak lumber has been produced recently at about one to two million board feet per year.

Wine is frequently matured in wooden tanks, casks, and vats to enhance its quality. During this aging period, the container must minimize loss of the wine through seepage and evaporation. The anatomical structure of white oaks, in general, is peculiarly well suited in this regard. As sapwood is changed to heartwood, cell elements are formed that effectively plug the principal openings in the wood. Since these occlusions, or tyloses, are part of the heartwood formation process, only heartwood is suitable (see fig. 1).

A further limit results from the fact that white oak is much more permeable in the radial than in the tangential direction relative to the trunk cross-section, because of conducting elements, called rays. These are not effectively blocked, and therefore quartersawn or riftsawn material must be used.

Although much is known about the properties of California white oak, little information is available on its permeability. A study to evaluate this wood for wine cooperage was undertaken in response to an inquiry from a vintner who wished to produce a California wine in California oak vats. The effect on wine quality was not evaluated in this study.

Procedure

A wood specimen was used to close a pressure cup filled with a 12 percent solution of ethanol in water (fig. 2). The

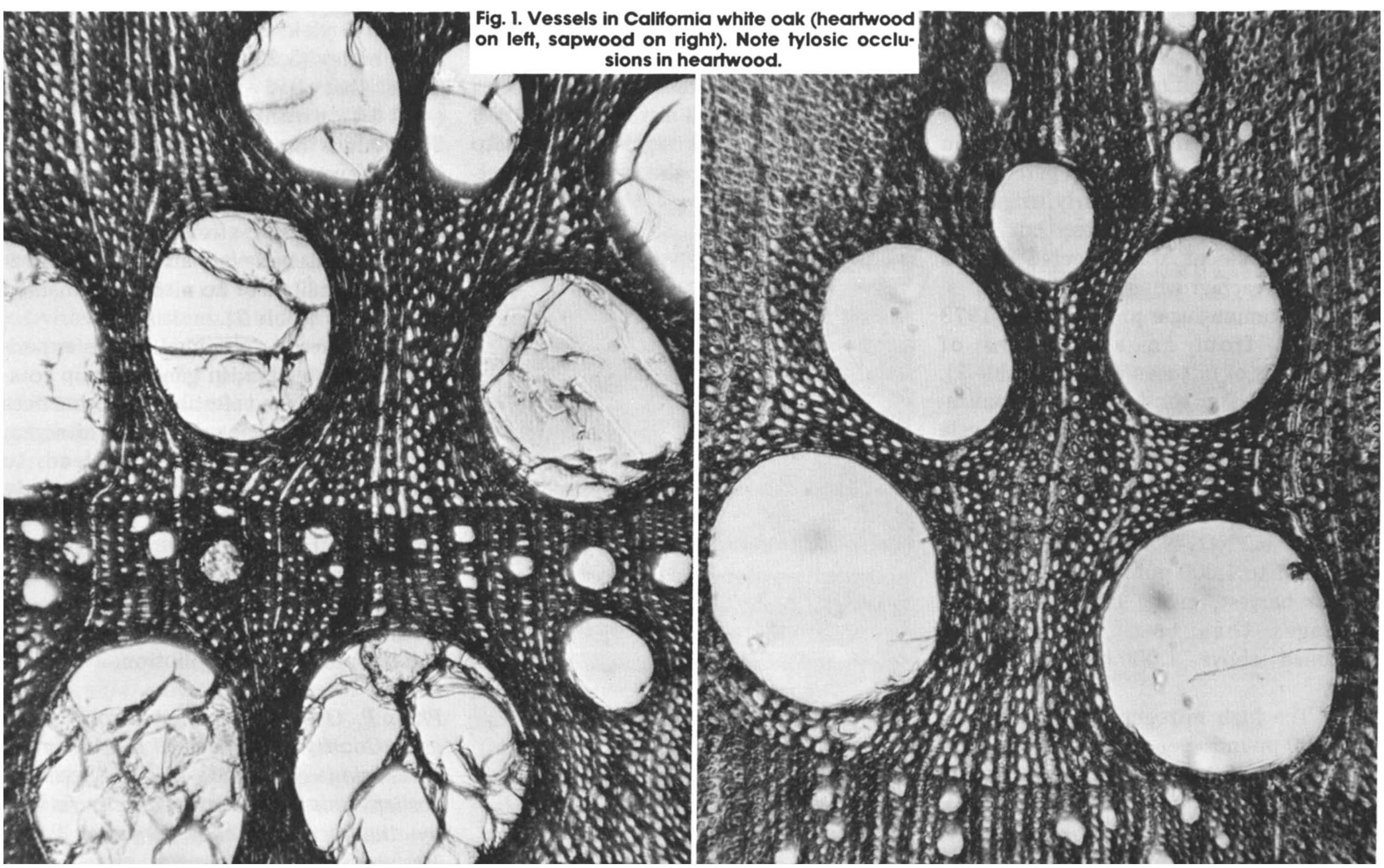

Fig. 1. Vessels in California white oak (heartwood on left, sapwood on right). Note tylosic occlusions in heartwood.

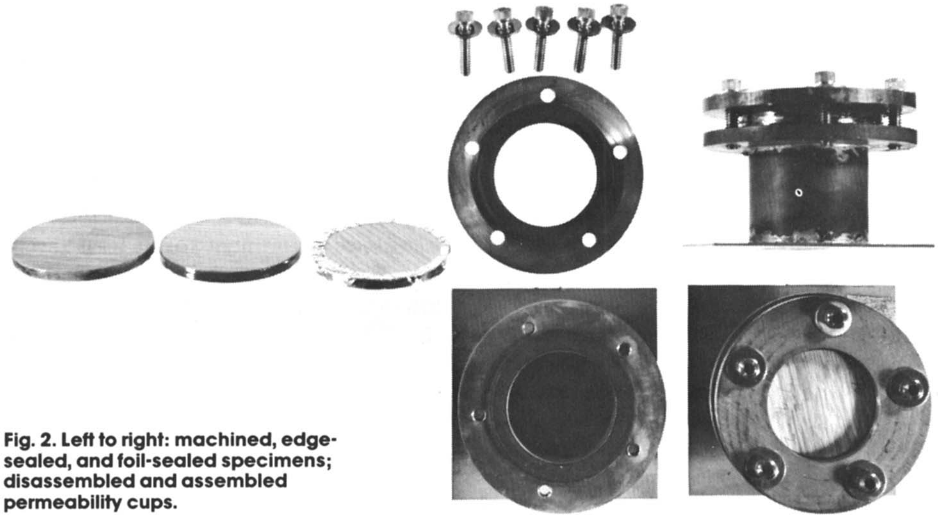

Fig. 2. Left to right: machined, edge-sealed, and foil-sealed specimens; disassembled and assembled permeability cups.

filled cups were inverted and placed in a constant atmosphere of 70° F and 65 percent relative humidity. Weight loss over time was recorded.

Both flatsawn and quartersawn boards were tested, and similar pieces of eastern white oak (*Quercus alba*) were included for comparison. The test material was surfaced to the desired thickness, and the discs cut from it were carefully inspected for defects, such as checks and cross-grain, that might affect permeability. Disc edges were sealed with a commercial end sealer and then aluminum foil.

Three consecutive series of tests were conducted. The first used a total of 20 specimens of flatsawn California white oak to evaluate the procedure, to measure permeability over time, and to determine the effect of thickness. Five thicknesses were tested.

The second, and main, series compared the two species. A total of 80 specimens included both flatsawn and quartersawn material from both species, but only one thickness.

The third series was similar to the first, except that quartersawn California white oak of greater thickness was used. Four thicknesses were tested, using a total of 24 specimens.

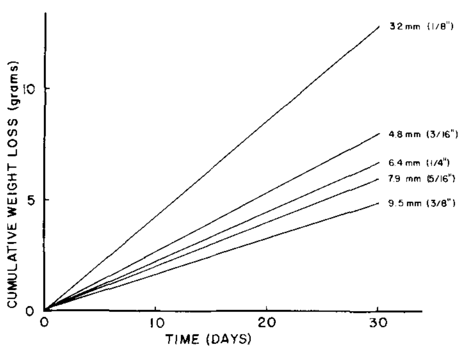

Fig. 3. Loss of solution as affected by thickness in California white oak flatsawn heartwood. Flow area = 20 square centimeters (3.1 square inches).

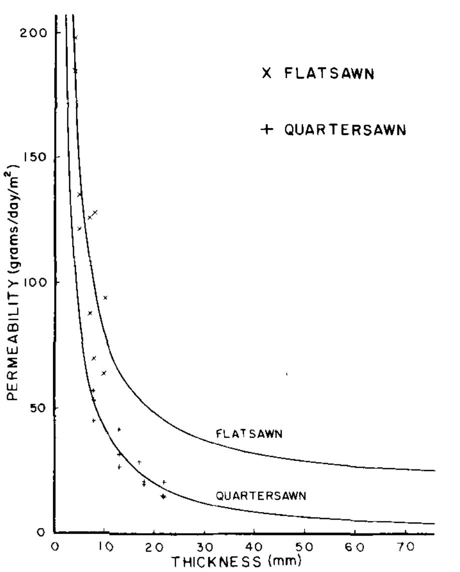

Fig. 4. Permeability of California white oak heartwood.

Results

Figure 3 presents data from test series 1 and shows the steady state flow through the wood over time. Table 1 summarizes test series 2. Regression equations and correlation coefficients for data from test series 1 and 3 are presented in table 2 and shown in figure 4, extrapolated to greater thicknesses than tested.

Discussion

The similarity of the tyloses and their distribution in California and eastern white oak has been known for 30 years or more. The results of this permeability study agree with that knowledge, and it is apparent that:

- The permeability of a given piece of wood does not change over time but establishes a steady state rate of flow.
- The rate of flow decreases as wood thickness increases.
- Quartersawn material is less permeable than flatsawn.
- Quartersawn eastern and California white oak are about equally permeable. In these tests, California white oak had a slightly more variable permeability, but the average was slightly lower. Differences between the species were not statistically significant.

It can be concluded that California white oak should be suitable for wine containers from the aspect of stave permeability, but studies of effects of this wood on wine quality need to be made. The relatively larger variability indicates that an occasional weeping stave will be encountered. However, even with these staves, losses should average less than for similar eastern white oak containers.

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TABLE 1. COMPARISON OF FLOW THROUGH FLATSAWN AND QUARTERSAWN CALIFORNIA AND EASTERN WHITE OAK

Material	Average loss per day per square meter[1] (grams)	Standard deviation	Difference from quartersawn eastern white oak[2]
Flatsawn			
California	121.98	40.47	*
Eastern	85.15	10.44	*
Quartersawn			
California	64.28	21.07	n.s.
Eastern	68.54	12.64	–

[1] Specimen thickness = 5 mm (0.195 inch)

[2] n.s. = not significantly different; * = significant at 5 percent level.

TABLE 2. PERMEABILITY OF QUARTERSAWN CALIFORNIA WHITE OAK TO 12 PERCENT ETHANOL IN WATER, AT 70° F AND 65 PERCENT RELATIVE HUMIDITY

Grain angle	Regression equation (grams lost/day/square meter)	Correlation coefficient (r^2)
Flatsawn	$17.20 + \frac{607.54}{\text{thickness (mm)}}$	0.82
Quartersawn	$-1.30 + \frac{432.72}{\text{thickness (mm)}}$	0.89