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Assessment of Absorption Property for Five Species According to Soaking Conditions for Manufacturing a Cask for Ripening Traditional Liquor[1]

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ABSTRACT

To study the suitability of chestnut as a cask for ripening traditional liquors, the absorption property for pure water, liquor with 30% alcohol content and ethanol with 95% alcohol content were investigated for five species. Oriental oak had the greatest amount of liquid absorption while chestnut had the smallest amount. The absorption amount linearly increased with increasing soaking time. The absorption amounts for each section were greatest in RT plane, and the difference between LR plane and LT plane was very small for all soaking conditions. The anisotropy of absorption amount for five species was greatest in Japanese cedar and was smallest in white mulberry on the whole. And the change of absorption amounts according to soaking conditions tended to decrease in softwoods and increase in hardwoods, and the difference among wood species was not clear. From this result, it was found that chestnut with a small absorption amount, regarding of soaking behavior, was a good material as a cask for ripening traditional liquors, whereas small diameter oriental oak with a great absorption amount was not suitable in this purpose.

Key words: Chestnut, absorption amount, soaking condition, cask, section.

INTRODUCTION

Vessels for ripening traditional liquors have been manufactured from various materials such as wood, soil, plastic and metal etc. Wood of them has been used as a material for ripening and storage of general liquors as well as traditional liquors. Especially white oak which water absorption is small because the tyloses in the vessel are well developed is widely used as barrels for ripening whiskies (Panshin and Zeeuw 1977; Haygreen and Bowyer 1989). However, wood is an anisotropic material that has very different physical and mechanical properties due to wood fiber arranging directions in the cell structure unlike other isotropic materials, and their properties also show the difference among wood species (Nakano 1958a, 1958b; Fushitani et al. 1985). These properties must be considered for using effectively wood as a vessel such as casks for ripening traditional liquors. As wood is a porous material which has strong hydrophilic property in its elements, its contact angle is near 0 and the absorption of water occurs in tracheal tissue and cell lumen when wood is soaked in water (Lee 1968). The water absorption property of wood means the property that cell lumen and intercellular space are full with water by capillary phenomenon, and in generally shows amount of water absorption per the unit area. The research for water absorption of wood is

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very important for ripening of traditional liquors, whereas the accumulations of the research are few and most researches are limited to pure water and organic compounds for wood preservation (Yamagishi 1956; Maku 1956; Ito 1958; Lee 1968). Moreover, there are little researches for absorption property of wood for three sections under various soaking conditions according to alcohol contents.

Therefore, in order to study the suitability of chestnut as a cask for ripening traditional liquors, the absorption properties were investigated for pure water, liquor with 30% alcohol content and ethanol with 95% alcohol content, respectively, using three hard woods and two soft woods.

MATERIALS AND METHODS

Materials

Five species with different densities were selected for this study. They included three hardwoods: chestnut (*Castanea crenata* Sieb. et Zucc.), oriental oak (*Quercus variabilis* Blume), white mulberry (*Morus alba* Linnaeus), and two softwoods: Japanese cedar (*Cryptomeria japonica* D. Don) and Japanese cypress (*Chamaecyparis obtusa* Endl.).

Water and alcohol absorption properties measurement

The rectangular parallelepiped specimens of 30mm (T) × 30mm (R) × 100mm (L) were manufactured from five species air-dried for more than one year, and the densities of five species were measured after conditioning more than 2 weeks in a room maintained at 20℃ and 65% RH.

For measuring the amounts of water and alcohol absorption of longitudinal-radial (LR) and longitudinal-tangential (LT) planes, two quarter sawn planes and flat sawn planes in the rectangular parallelepiped specimens were selected, and the other planes were completely waterproofed with silicon. And, for radial-tangential (RT) plane, one cross-section was selected to measure and other planes were completely waterproofed with silicon. Three cisterns which were able to control the temperature were prepared and the cisterns were filled with pure water, liquor with 30% alcohol content and ethanol with 95% alcohol content, respectively. The temperatures of the cisterns were controlled with 25℃. The specimens made with five species were soaked with 50mm depth from the surface of the water and ethanol, and measured for 48 hours. The amount of water and alcohol absorption was calculated as the following next equation:

$$Q = (W_{nh} - W_1)/A \qquad (1)$$

where, W_{nh} is the weight of specimen in measuring time after soaking (g), W_1 is the weight of the specimen after waterproofing (g), A is total area of the absorbed plane (cm^2).

RESULTS AND DISCUSSIONS

Absorption property for five species soaked in pure water

The results of water and alcohol absorption amount tests for five species are shown in Table 1, and typical examples for the curves of water absorption amount for five species with soaking time are shown in Fig. 1.

Table 1. Results of measuring the amount of water absorption for five species soaked in pure water, liquor with 30% alcohol content and ethanol with 95% alcohol content.

Species	Planes	Soaking in pure water			Soaking in 30% alcohol			Soaking in 95% alcohol		
		ρ (g/cm^3)	Q(24) (g/cm^2)	Q(48) (g/cm^2)	ρ (g/cm^3)	Q(24) (g/cm^2)	Q(48) (g/cm^2)	ρ (g/cm^3)	Q(24) (g/cm^2)	Q(48) (g/cm^2)
Japanese cedar	LT	0.351	0.092	0.141	0.340	0.087	0.135	0.359	0.060	0.098
	LR	0.343	0.074	0.116	0.365	0.099	0.158	0.341	0.064	0.107
	RT	0.349	1.61	2.20	0.340	1.52	1.89	0.340	0.832	1.17
Japanese cypress	LT	0.465	0.092	0.141	0.466	0.116	0.157	0.478	0.087	0.122
	LR	0.478	0.048	0.081	0.479	0.073	0.103	0.480	0.085	0.123
	RT	0.478	0.593	0.930	0.480	0.974	1.25	0.478	0.961	1.23
Chestnut	LT	0.639	0.045	0.065	0.633	0.040	0.057	0.633	0.025	0.046
	LR	0.649	0.047	0.070	0.626	0.035	0.051	0.641	0.035	0.057
	RT	0.609	0.206	0.328	0.637	0.238	0.352	0.627	0.50	0.742
White mulberry	LT	0.661	0.113	0.173	0.675	0.070	0.102	0.661	0.036	0.062
	LR	0.646	0.092	0.141	0.651	0.054	0.079	0.652	0.045	0.074
	RT	0.660	0.362	0.571	0.646	0.282	0.423	0.657	0.429	0.712
Oriental oak	LT	0.888	0.131	0.201	0.889	0.132	0.197	0.898	0.114	0.176
	LR	0.895	0.111	0.176	0.888	0.120	0.175	0.887	0.133	0.186
	RT	0.888	0.830	1.61	0.882	1.35	1.90	0.880	2.10	2.66

Note: W: width, H: Height, L: Length, LT: Longitudinal-Tangential plane, LR: Longitudinal -Radial plane, RT: Radial-Tangential plane, ρ: Density, Q(24) and Q(48): The amounts of water absorption in 24 and 48 hours, respectively. Each value is the average of three measurements.

The amount of water absorption for five species linearly increased with the increase of the soaking time in pure water. The amount of water absorption of five species at 24 hours and 48 hours was in the order RT plane > LT plane > LR plane, and showed the difference among three sections. The difference between RT plane and LT plane or LR plane was remarkable, whereas the difference between LT plane and LR plane was small. At 48 hours soaking time, the amounts of water absorption of LR planes for five species showed the greatest amount in oriental oak (0.176 g/cm^2) and the smallest amount in chestnut (0.070 g/cm^2). Their amounts were in the order oriental oak > white mulberry > Japanese cedar > Japanese cypress > chestnut. For the LT plane, the amount of water absorption for five species showed the greatest amount in oriental oak (0.201 g/cm^2) and the smallest amount in chestnut (0.065 g/cm^2). Their amounts were in the order oriental oak > white mulberry > Japanese cedar = Japanese cypress > chestnut. This result tended to be similar to that for LR plane. For RT plane, the amount of water absorption showed the greatest amount in Japanese cedar (2.20 g/cm^2), and showed the smallest amount in chestnut (0.328 g/cm^2). Their amounts were in the order Japanese cedar > oriental oak > Japanese cypress > white mulberry > chestnut. It was slightly different from the order for LR and LT planes, whereas that for chestnut showed the smallest amount and was same as in LR plane and LT plane. The reason why the chestnut had the smallest amount is considered because the vessel blockade occurred by tyloses developed of old-aged chestnut. Against expectation, oriental oak for all sections showed the greatest amount, this is considered because juvenile wood in the specimen was contained by using small diameter oriental oaks. The anisotropy of water absorption (ratios of LR and LT planes to RT plane)

indicated the greatest value in Japanese cedar and lowest value in white mulberry. For the Japanese cedar, the amount of water absorption for RT plane was 19.0 times and 15.6 times greater than in LR plane and in LT plane, respectively. And that of LR plane was 0.82 times of LT plane. This corresponded to past research (Lee, 1968). For white mulberry, the amount of water absorption for RT plane was 4.05 times and 3.30 times greater than in LR plane and in LT plane, respectively. And that of LR plane was 0.82 times of LT plane. The anisotropy of water absorption for each section was caused by cell structure of wood. Namely, wood fibers for three sections have different cutting planes because most wood cells shaped like a pipe are arranged to longitudinal direction and a few rays are only arranged to radial direction, therefore, each section of woods shows different water absorption.

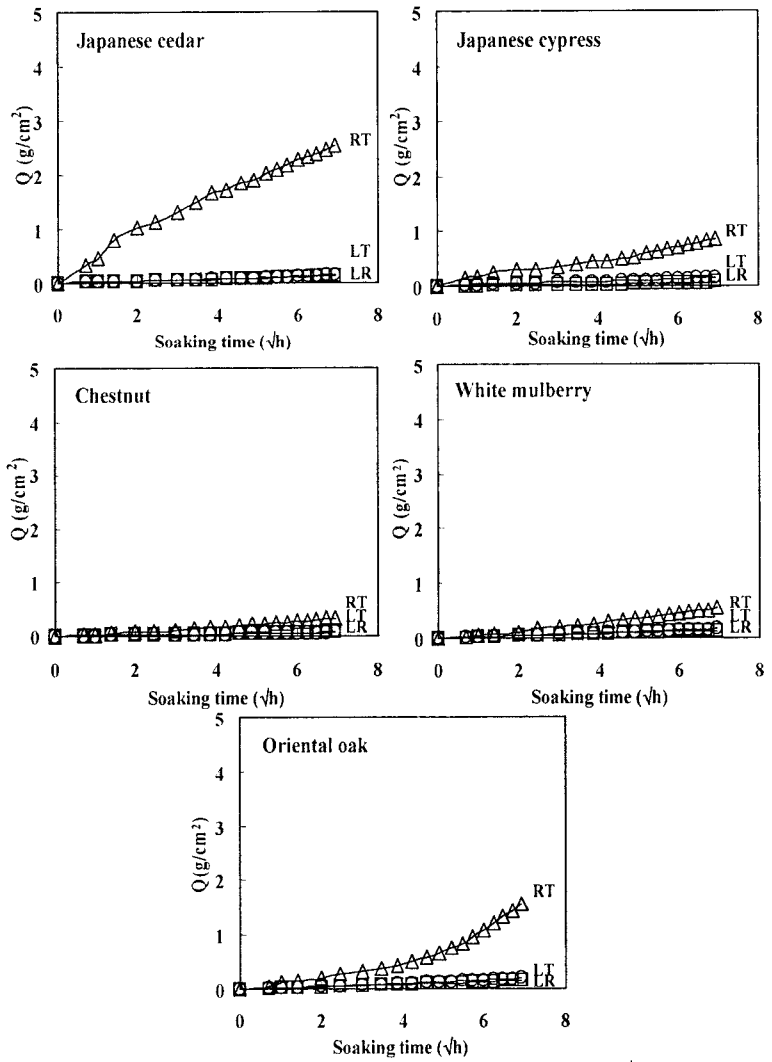

Fig.1. Relationships between absorption amount (Q) and soaking time (√h) of five species soaked in water. Notes; RT: Radial-Tangential plane, LT: Longitudinal-Tangential plane, LR: Longitudinal-Radial plane.

Absorption property for five species soaked in liquor with 30% alcohol content

The results of alcohol absorption test for five species soaked in liquor with 30% alcohol content are shown in Table 1, and typical examples for the curves of alcohol absorption amount with soaking time are shown in Fig.2.

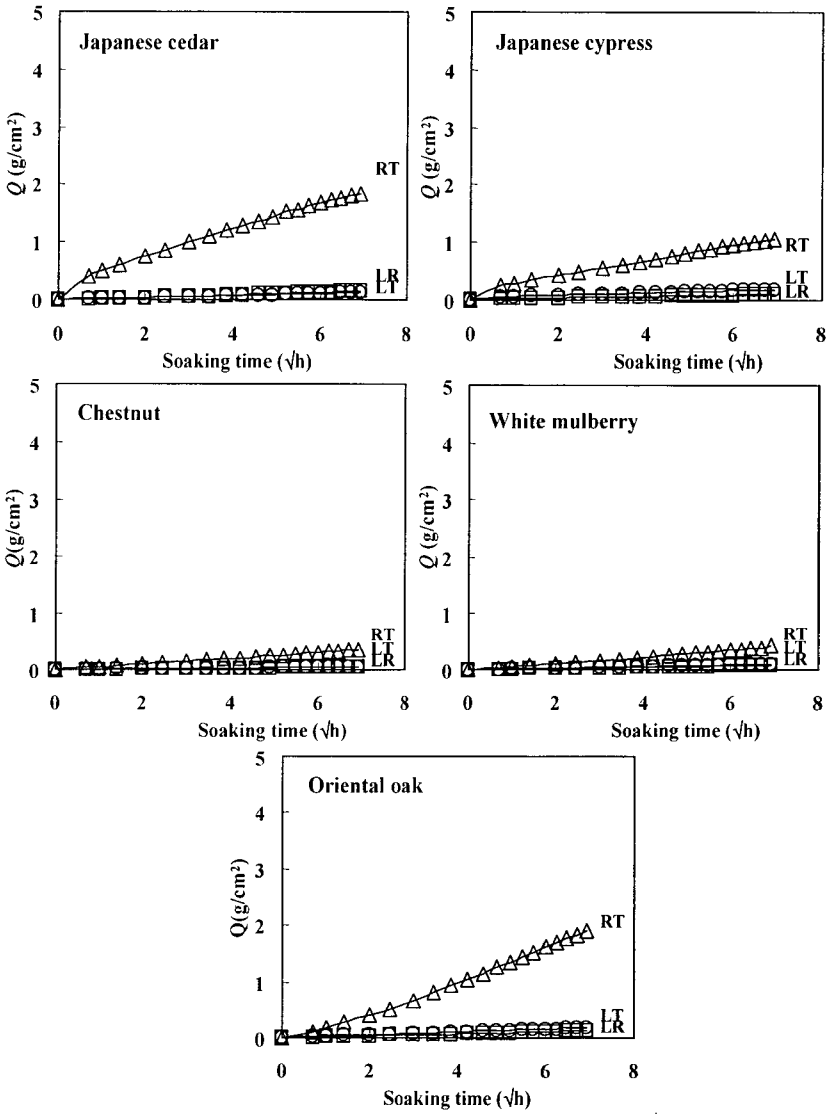

Fig.2. Relationships between absorption amount (Q) and soaking time (√h) of five species soaked in liquor with 30% alcohol content for ripening fruit wine. Note; LT, LR and RT are the same as in Fig.1

The amount of alcohol absorption for five species linearly increased with increasing the soaking time like that of pure water. The absorption amounts for five species at 24 hours and 48 hours had the difference among three sections like that soaked in pure water. The RT plane was

markedly greater than in LT plane or LR plane, and the difference between LT plane and LR plane was small. At 48 hours soaking time, the absorption amounts of LR planes for five species showed the greatest amount in oriental oak (0.175 g/cm^2) and the smallest amount in chestnut (0.051 g/cm^2). Their amounts were in the order oriental oak > Japanese cedar > Japanese cypress > white mulberry > chestnut. For the LT plane, the absorption amount for five species showed the greatest amount in oriental oak (0.197 g/cm^2) and the smallest amount in chestnut (0.057 g/cm^2). Their amounts were in the order oriental oak > Japanese cypress > Japanese cedar > white mulberry > chestnut. This result tended to be similar to that for LR plane. For RT plane, the absorption amount showed the greatest amount in oriental oak (1.90 g/cm^2), and showed the smallest amount in chestnut (0.352 g/cm^2). Their amounts were in the order oriental oak > Japanese cedar > Japanese cypress > white mulberry > chestnut. It tended to be similar to LR and LT planes. That for chestnut showed the smallest amount for all sections like soaking in pure water. This result indicates that the chestnut is able to use a cask for ripening traditional liquor. The anisotropy of absorption amount showed the greatest value in Japanese cedar and lowest value in white mulberry like that of pure water. For the Japanese cedar, the amount of water absorption for RT plane was 12.0 times and 14.0 times greater than in LR plane and in LT plane, respectively. And that of LR plane was 1.17 times of LT plane. For white mulberry, the amount of water absorption for RT plane was 5.34 times and 4.15 times greater than in LR plane and in LT plane, respectively. And that of LR plane was 0.78 times of LT plane. The difference between LR plane and LT plane for both species were small. It was found that this value for Japanese cedar decreased than that soaked in pure water, and other species were equal or slightly increased. However, it was found that it tended to be similar to that soaked in pure water on the whole.

Absorption property for five species soaked in ethanol with 95% alcohol content

The result of alcohol absorption test for five species soaked in ethanol with 95% alcohol content are shown in Table 1, and typical examples of the curves of alcohol absorption amount with soaking time are shown in Fig. 3.

The amount of alcohol absorption for five species linearly increased with increasing the soaking time. The absorption amounts for three sections for five species at 24 and 48 hours were the order RT plane > LR plane > LT plane. This was different from two soaking conditions mentioned above, whereas the difference between LR plane and LT plane was very small.

At 48 hours soaking time, the absorption amounts of LR planes for five species showed the greatest amount in oriental oak (0.186 g/cm^2), and showed the smallest amount in chestnut (0.057 g/cm^2). Their amounts were in the order oriental oak > Japanese cypress > Japanese cedar > white mulberry > chestnut. For the LT plane, the absorption amount for five species showed the greatest amount in oriental oak (0.176 g/cm^2), and showed the smallest amount in chestnut (0.046 g/cm^2). Their amounts were in the order oriental oak > Japanese cypress > Japanese cedar > white mulberry > chestnut. This result tended to be similar to that for LR plane. For RT plane, the absorption amount showed the greatest amount in oriental oak (2.66 g/cm^2), and showed the smallest amount in white mulberry (0.712 g/cm^2). Their amounts were in the order oriental oak > Japanese cypress > Japanese cedar > chestnut > white mulberry. The absorption amount of chestnut was greater than that of white mulberry, whereas the difference was very small. The anisotropy of absorption amount indicated the greatest value in chestnut and lowest value in white mulberry. For chestnut, the absorption amount for RT plane was 13.0 times and 16.1 times greater than in LR plane and in LT plane, respectively. For white mulberry, the absorption amount for RT plane was 5.34 times and 4.15 times greater than in LR plane and in LT plane, respectively. The difference between LR plane and LT plane for both species were small. It was found that these values for softwoods decreased than that soaked in pure water and the liquor with 30% alcohol content for ripening fruit wine, and

inversely increased in three hardwoods. From the results, chestnut had a small absorption amount, regardless of alcohol content. This result indicates that chestnut is a good material as a cask for ripening traditional liquors.

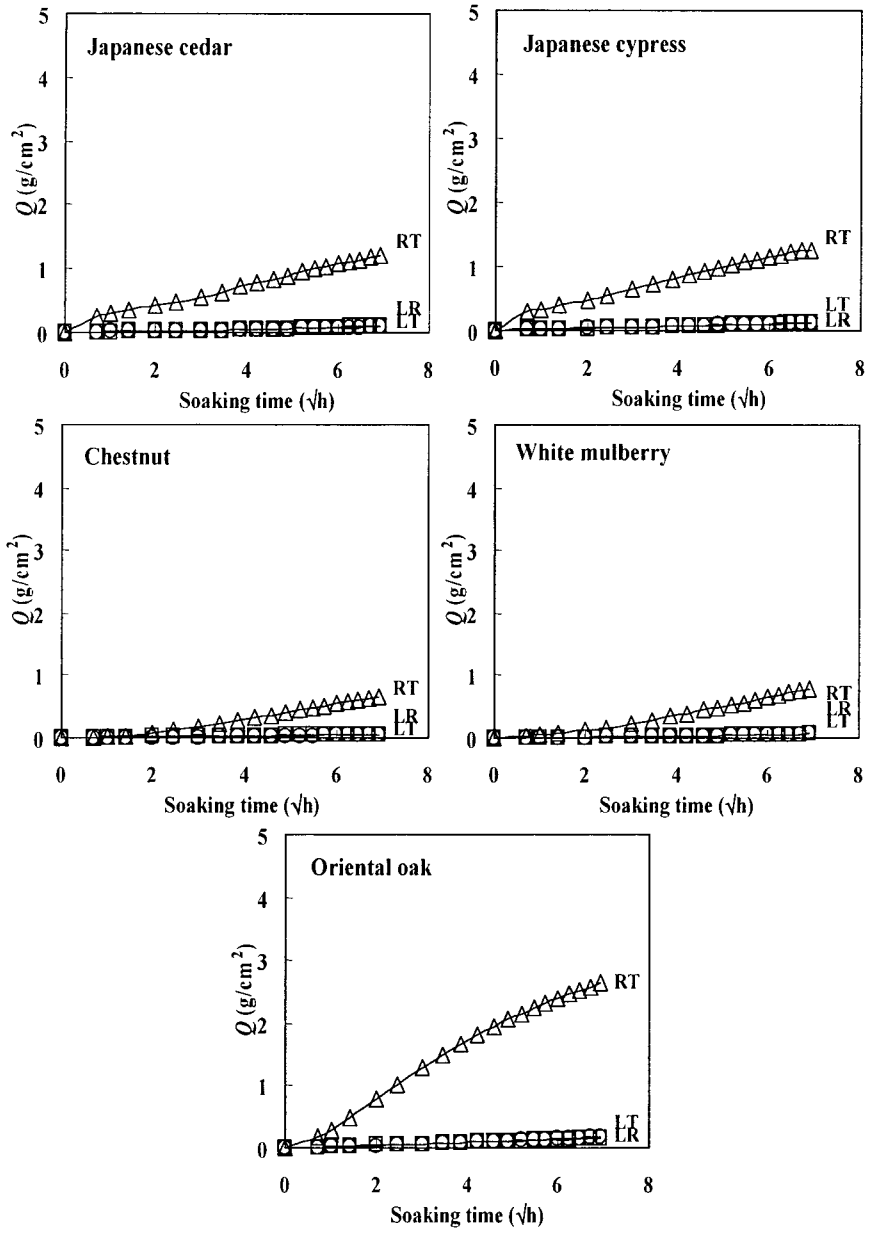

Fig.3. Relationships between absorption amount (Q) and soaking time (√h) of five species soaked in ethanol with 95% alcohol content. Note; LT, LR and RT are the same as in Fig.1

CONCLUSIONS

To study the suitability of chestnut as a cask for ripening traditional liquors, the absorption property of water and alcohol for five species containing chestnut were investigated. The amounts of water and alcohol absorption linearly increased with increasing soaking time, and oriental oak had the greatest amount for most species and chestnut had the smallest amount, regardless of soaking conditions. The anisotropy of absorption amount for five species was greatest in Japanese cedar and was smallest in white mulberry. The change of absorption amounts according to soaking conditions tended to decrease with increasing alcohol percentage of the soaking liquids in two softwoods, whereas that of three hardwoods tended to increase, and it was found that the change of absorption amounts according to soaking conditions was not clear. From this result, it was found that chestnut which had the smallest absorption amount of five species because vessel blockade occurred by developed tyloses of old-aged chestnut is a good material as a cask for ripening traditional liquors. However, against expectation, a small diameter oriental oak containing juvenile wood parts had a great absorption amount, and was not suitable with a ripening cask.

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