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The Relationships between Density and Shrinkage of Sessile Oak (Quercus Petraea L) Used For Alcohol Barrels: (A Case Study of Wood That Grows In the Republic Of Kosovo)

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Abstract

This study presents relations between density and shrinkage of sessile oak (Quercus Petraea L.) a wood species that is used in the wood processing industry in Kosovo, especially for alcohol barrels. This case study is focused on two moisture contents: 12% of moisture content and oven dried. Sessile oak wood is used at 12 % moisture to produce barrels, whereas in oven dry conditions are used for scientific studies. Our study results/findings indicate important data that can be used by the wood processing industrie and manufacturers of sessile oak barrels.

Keywords: barrels, heartwood**,** staves.

1. Introduction

The total standing volume of wood in Kosovo (in all dimensions) is 52 million m^3 or $31m^3$ per person, with an average 113m per hectare. Out of the total volume there are about 40.4millionm^3 of wood with a diameter greater than7cm.

The most important types of woods that grow in Kosovo are Beech wood (Fagus) with a volume of 15.96 mil m^3 and oak wood (Quercus), with 9.67 mil m^3. Oak is a slow-growing tree. Due to its good characteristics, (having some chemical components which are used to flavor the wine barrels, beautiful texture during radial and tangential cutting direction and other good mechanical properties) the sessile oak tree is fairly used in the wood processing industry. This type of wood is mostly used to make doors, windows, flooring, barrels and many other products.

Oak is a slow drying wood, with tendency to split, mainly in the initial stages of drying. The oak wood is moderately strong to very strong during the handwork or machinery. It depends on wood conditions, if wood is wet or dry. Green wood is processed more easily, but the dust arising from the wood processing covers the cutting instruments. Working with dried wood is pretty difficult and the instrument should be unsharpened.

Oak heartwood is moderately strong and contains many chemical compounds. Oak heartwood is very rich in tannin and this is the reason that oak heartwood is not needed to be treated with chemicals against fungal and insects if used in internal environments**.**

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Sapwood oak is soft and susceptible to attack by fungus and insects, as well do not keep heavy weights and due to this is not allowed to be used in construction. As an effect of compounds during the use of green wood, metals in contact with wood it undergoes to the process of corrosion. The density has an overriding importance among the physical and mechanical properties because density is closely connected with the most physical and mechanical properties (Aguilar et al.2003).

Density can be seen as a universal material property therefore it would be very important to have information about it many times when qualifying the assortment of logs in the forest. Wood density can be described among others by the density of absolute dry wood, wet or green density, air dry density and basic density (Molnar 2004). Vavrcik et al. (2010) examined the density differences between pedunculate oak and the sessile oak. They found that in the case of the same width of the annual ring the sessile oak has a bigger proportion of latewood and has a bigger density, and also established that the density does not only depend on the proportion of latewood but on its quality too.

Wood density is influenced by several factors which are also in correlation with each other: wood species, moisture content, altitude, climate etc, whereas factors which have influence on shrinkage of wood are: wood species, moisture content, fiber direction, thickness of cell walls etc.

In general, researchers agree that wood density is one of the most important factors affecting wood quality (Keith 1986; Tsoumis 1991). The methodology for determining the variation in specific gravity within and between trees was studied by Mutibaric and Cemerikic (1971), and Panetson et al. (1969). They studied the influence of wood raw material on shrinkage and swelling properties; however, until now only a few studies to examine the relationship between wood density and wood shrinkage have been carried out, especially for the Quercus Petraea L, which is used in general in the industry of producing wine barrels.

Materials and Methods

All the trees were randomly selected, and were examined for any possible damage or attack by fungus or insects. 175 samples were chosen from 7 oak logs (25 samples for every logs), which are divided into three groups depending of sample position on log. Some characteristics of the places where the logs are taken are shown in the table number 1.

Table 1: The average temperature in the regions where the samples are taken Cutting trees and sampling was done in April 2014.

Climate type	Altitude	Average	Temperature0C		The size of	Age in	Annual
Continental	m	Temperature0C	Minimal	Maximal	Annual rings	Years	Rainfall mm3
	600-800	10.3	-26	+33	2,032mm	50	600-700

The samples of all groups are taken from the pith towards the periphery, figure 1., with dimensions 20×20×20mm distance of 20mm from each other according to the standard ASTM-D143.Since sapwood wood is not used for barrel wine, and then it is not taken in the study.

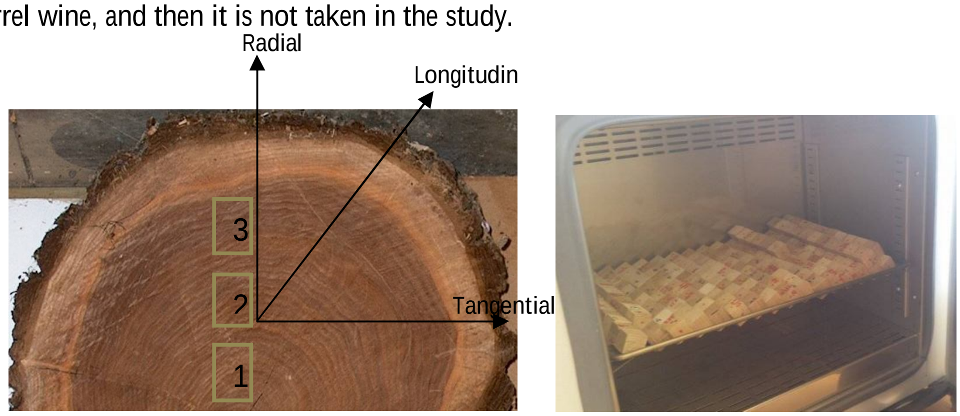


Figure 1: Sample position in the log and oven dry

Measurement of samples in dimensions and weight is made immediately after sawing in order to keep the moisture on the fiber saturation point. Samples were dried in thermostat at 12% moisture and oven dry.(Temperature 102 ± 3^{0}C the attainment of constant mass is reached with changes in weight ± 0,1gr).

The moisture content of samples is calculated by the formula:

$$Wood\ Moisture\ (\%) = \frac{G_l - G_0}{G_0} \times 100\ [\%] \qquad [1]$$

Were:

G_l-Weight of moisture wood,

G_0-Weight of oven dried wood.

Wood shrinkage can be calculated using the following formula:

$$Shrinkage\ (\%) = \frac{Initial\ dimensions - Final\ dimensions}{Initial\ dimensions} \times 100\% \qquad [2]$$

Wood density is calculated based on the ratio of the dimensions of the wood (volume) and the sample weight in moisture 12% and oven dry:

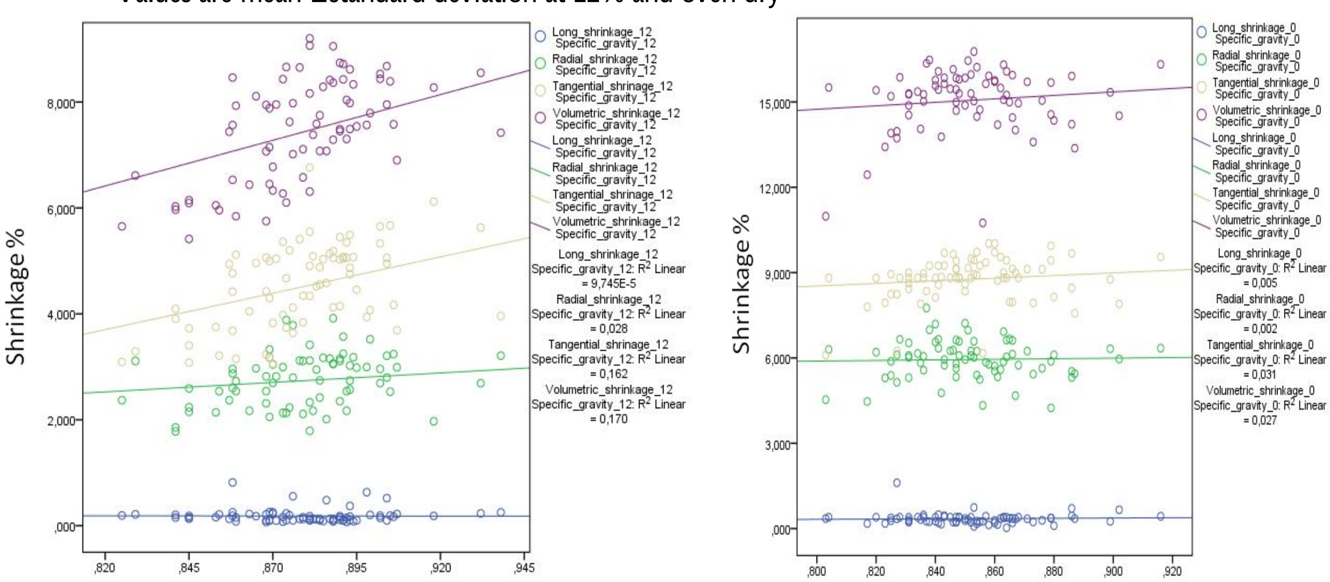
$$\delta = \frac{Mass}{Volum} (gr/cm\text{^}3) \qquad [3]$$

Results and Discussions

Table 2: Variation in wood density and shrinkage in various directions, according to distance from the pith to the bark in Qurcus Petraea L. Values are mean ±standard deviation at 12% and oven dry.

	Moisture content 12%			Oven dry			Average	
	First group	Second group	Third group	First group	Second group	Third group	at 12 %	at 0%
Density Kg/m3	880,01±0,024	861,3±0,018	881,4±0,011	864,9±0,043	842,7±0,016	848,3±0,016	880,03±0,018	851,97±0,025
Longitudinal Shrinkage %	0,18±0,129	0,19±0,043	0,11±0,12	0,36±0,19	0,40±0,26	0,29±0,10	0,19±0,118	0,35±0,183
Radial Shrinkage %	2,74±0,505	2,61±0,567	2,83±0,48	5,88±0,59	6,35±0,63	5,60±0,59	2,74±0,502	5,94±0,603
Tangential Shrinkage %	4,53±0,802	3,73±0,477	4,99±0,33	8,68±0,70	8,53±0,73	9,09±0,79	4,53±0,539	8,77±0,740
Volumetric Shrinkage %	7,45±0,984	6,53±0,80	7,92±0,67	14,92±1,09	15,27±1,06	14,99±1,51	7,18±0,743	15,10±1,22

Values are mean ±standard deviation at 12% and oven dry



b. Wood b. Wood

Figure 2: The relationships between wood density and shrinkage of sessile oak in: longitudinal, radial, tangential and volumetric directions in moisture a. 12% and b. 0%.

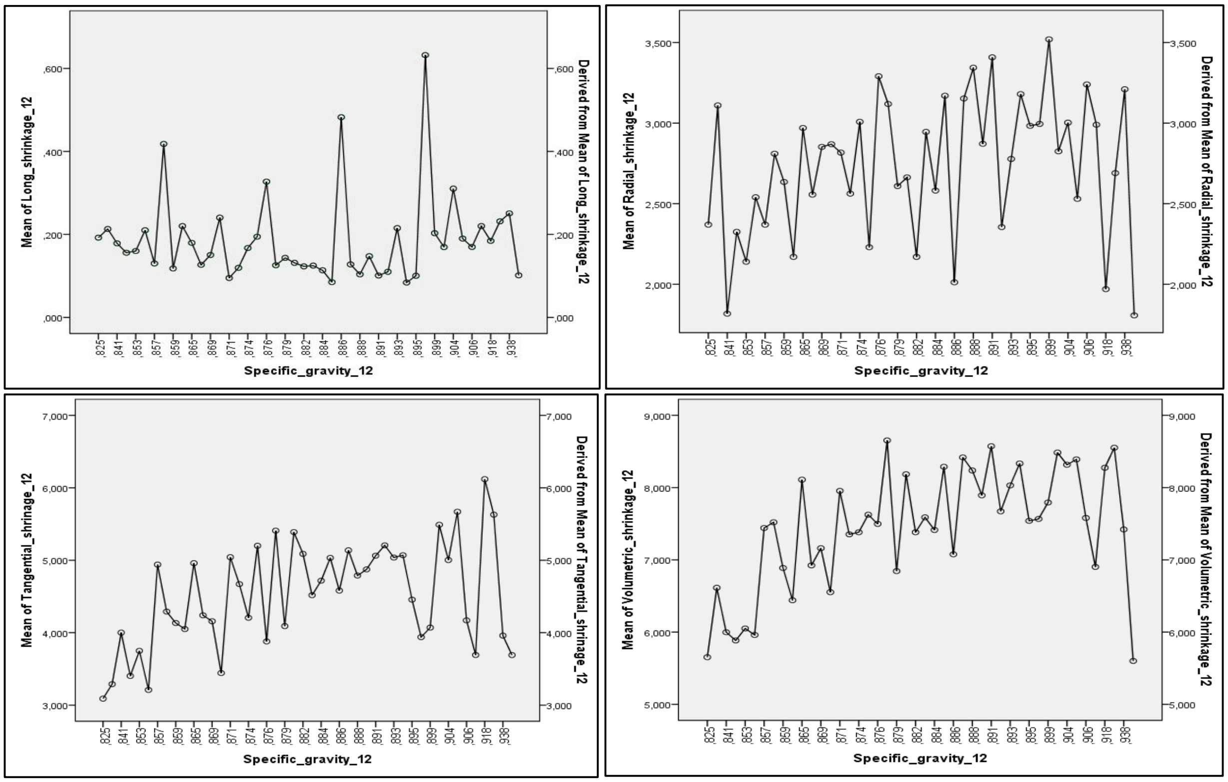


Figure 3a. Relationships between specific gravity and shrinkage of wood at 12% of moisture content.

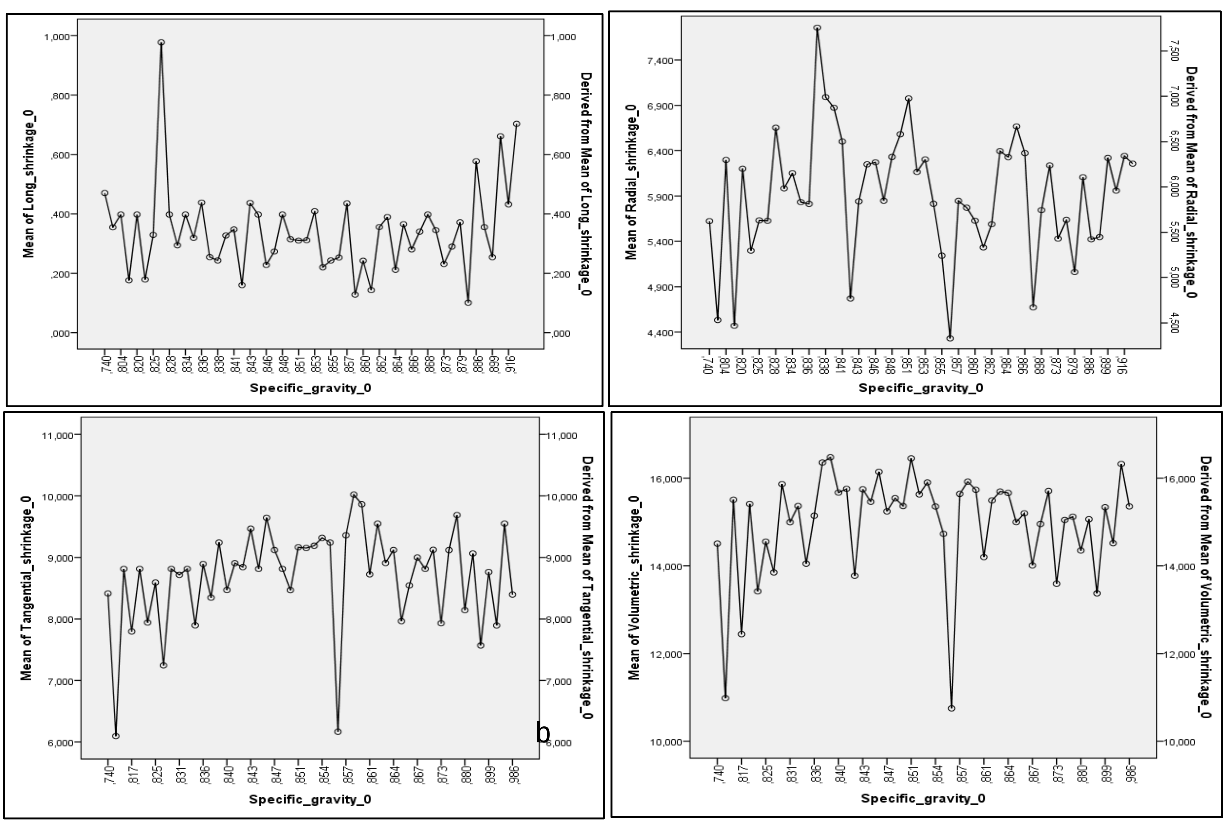


Figure 3b: Relationships between specific gravity and shrinkage of wood at 0% of moisture content.

The results in Table 2. Show that there is no correlation between the density and position of the samples on the tree included in the study, because in both cases as moisture 12%, as well as in absolute moisture content the samples of the second group (middle) have shown lower density.

In longitudinal direction at 12% moisture, there is a negative correlation between density and shrinkage i.e. samples with lower density have shrunk the most, while those with greater density have shrunk the least. In oven dry there is not shown a positive or negative correlation between density and longitudinal shrinkage.

In radial direction at 12% moisture, there is a positive correlation between density and shrinkage, since samples with higher density have shrunk more than those with lower density. In absolute moisture there is no correlation between density and radial shrinkage.

In tangential direction at 12% of moisture content there is a positive correlation between density and shrinkage. In oven dry conditions there is no correlation between density and tangential shrinkage.

In volumetric shrinkage at 12% moisture, there is a positive correlation between density and volumetric shrinkage, while in oven dry there is a negative correlation between density and volumetric shrinkage.

Figure 2 shows that in the averages of density and shrinkage there is a positive correlation between them in all directions, except the longitudinal direction at 12% moisture. This positive correlation is more pronounced at 12% moisture than in the absolute humidity.

Figure 3 shows detailed data between density and shrinkage in 12% and oven dry moisture.

Conclusions

Barrels' staves should be prepared from the middle part and the one closer to the center, whereas those for heads should be prepared from the outlying part. This is justified by the fact that the barrels are produced in 12% moisture and that staves are arranged in radial direction, while the study shows that the part that is shrunk the least is the middle part, then the central part and the peripheral part is the most that is shrunk, also in the case of alignment of planks in tangential order in 12% humidity, the same rule applies.

If a higher density is requested, then the samples of the third and first group have a higher density, whereas those of the second group are shown to be lighter.

No significant positive or negative correlation is noticed between samples separately, but there is an increasing tendency of positive correlation between density and shrinkage in all directions except in radial direction at 12% moisture.

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