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Effects of different drying environments on the dimensional stability of eucalyptus wood

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Abstract: Due to its hygroscopic properties, the wood material reach a certain equilibrium moisture content at various usage areas according to the existing relative humidity and adapting the weather conditions considering the temperature. For this reason, there could be shrinkages and swellings in wood material dimensions if it is not dried enough with respect to its intended purpose and place of use. Therewith, a number of deformations occur in wood material such as cracking, warping and split-up at joints. Because of the high amount of water found in eucalyptus, which is the subject of the study, it is known that it is one of the most late-drying trees and difficulties occur during its drying process. In this study, the effects of natural drying methods performed at different environments upon eucalyptus (*Eucalyptus camaldulensis*) timber' density and dimensional stability were investigated. Within this scope, sample timbers were stacked under two different atmospheres being open - closed environments and dried during a year. Then, measurements made on samples prepared according to standards showed that oven dry density, volume weight value, volumetric shrinkage and swelling percent of timbers dried at open environment (OE) were found averagely as 0.674 g/cm^3, 0.56 g/cm^3, 11.91%, 18.90%, while values of timbers dried at close environments (CE) were found as 0.737 g/cm^3, 0.63 g/cm^3, 10.89%, 17.14%. When evaluating the results of data using Independent-Samples T test analysis, it was determined that drying environment has formed significant differences at a level of ($p<0.05$) on density, swelling as well as volume weight value however, it has not significant effect on volumetric shrinkage.
Keywords: Natural drying, Eucalyptus, Dimensional stability, Volumetric shrinkage, Swelling, Density

1. Introduction

The eucalyptus tree planted with the aim of drying the bogs in Turkey is a fast growing species and therefore an important raw material used in the forest products industry nowadays. Eucalyptus, which is considered to be a packaging box in the past, is importantly now used in building constructions, railway traverses, coatings, furniture, chests, turning, agricultural tools, musical instruments, sports equipment, sandal and buckets. Despite many advantages, Eucalyptus wood has some disadvantages such as high swelling, low dimensional stability, and several drying problems limiting its use (Unsal et al., 2003; Bektas et al., 2008; Korkut et al, 2008; Kilic Ak, 2016).

Before final products are obtained, the water present in newly cut trees should be evaporated from wood. For this reason, the rough and fresh lumber sawn from the log must be dried. Depending on species, local weather conditions, dimensions and time of year when the material piled, natural-drying times vary widely. Temperature, rainfall and relative humidity all contribution to the drying process of wood piles. Also water loss slows down as wood water content decrease. Additionally, different log diameters and lengths, debarking and piling specifications may strongly affect natural-drying times (Simpson and Wang, 2004; Bown and Lasserre, 2015). The drying process has several important advantages such as reduces wood weight, stains, and decays, increases some strength properties, improves the application of adhesives and other chemicals. Besides, it improves dimensional stability of wood reducing shrinkage and swelling (FPL, 1999).

Wood normally shrinks as it dries and swells as it absorbs moisture. These changes in its dimensions are important to final usage area. The dimensional changes in wood are brought about by the shrinkage or swelling of the cells, or fibers, of which the wood is composed. The timber drying process should be well managed to ensure dimensional stability. For example, collapses are formed on the wood as a result of rapid drying. Therefore, shrinkage and swelling values can be varied.

The aim of this study was to determine differences between open-closed drying on the dimensional stability of eucalyptus woods grown in Turkey. For this reason, the shrinkage and swelling values of the wood samples dried in different environment were determined and compared with each other.

2. Material and methods

2.1. Drying process

The freshly sawn materials were obtained in Mersin-Karabucak Forest Sub-district Directorate. When the timbers were brought to environments, their starting moisture content (MC) varied between 57 to 72%. All the material consists in boards 3 m long, 15 cm width and 6 cm thickness. Air drying method was applied to the timbers stacked in Kahramanmaraş Province. Timbers were piled in two different environments: Open (OE) and Closed (CE). Drying process was began in summer period

(effective drying) on June and followed during one year. The data were taken from meteorological station for OE and Geratech DT-172 was used to measure temperature and relative humidity of CE.

2.2. Determining dimensional stability

When drying process ended, thirty specimens having a dimension of 20 × 20 × 30 mm were prepared for the each test. In order to determine dimensional stability, volumetric swellings and shrinkages in tangential and radial, and longitudinal directions were performed accordance with TS 4083-4084-4085-4086 standards. Also volume-weight value was calculated based upon TS 2472. The specimens were dried at the temperatures of 103± 2°C until they reached 0% moisture content. Then, in order to determine oven-dry density, they were weighed and their dimensions were measured. Changes in the cell wall thickness of the fibers was examined in order to determine effects on the dimensional stability.

2.3. Statistical analysis

The independent samples T-test was performed to determine the effect of different environments drying on the dimensional stability of eucalyptus wood.

3. Results and discussion

The temperature and relative humidity values, which are effective parameters in the drying process, were measured throughout a year and are given seasonally in Fig. 1 below. As can be seen in the figure, throughout drying process, average temperature in CE and OE were measured 19 and 20 °C, and relative humidity were 58 and 43%, respectively. In addition, the average annual rainfall and wind velocity values that are effective on OE were 2.70 mm and 2.10 m/sec, respectively. At the end of the effective drying period (summer), the moisture content of CE and OE were 12% and 9.8% whereas after one year, respective values were 13.3% and 14.5%, respectively.

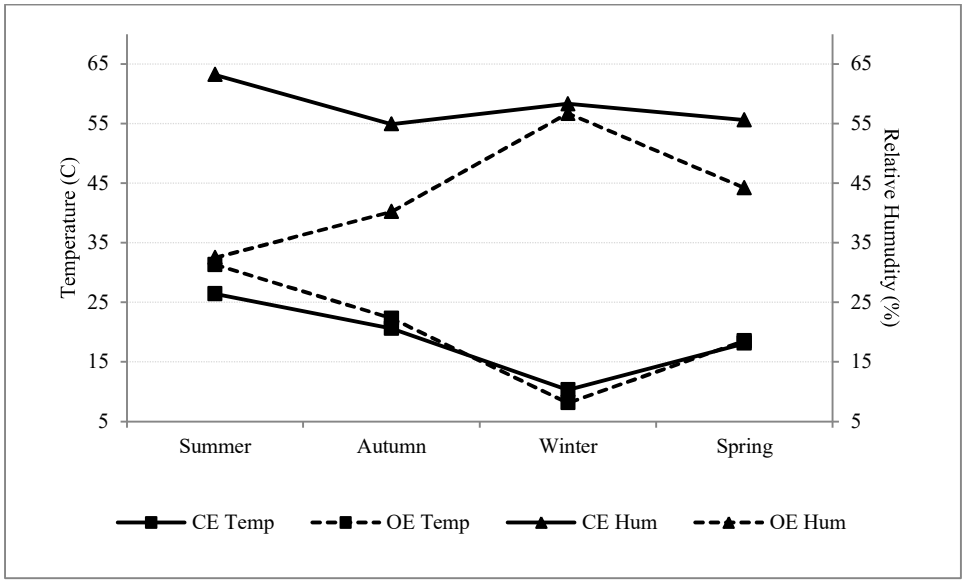

Figure 1. Temperature and relative humidity values of CE and OE

The findings obtained in the tests were analyzed by grouping according to drying environments, and evaluated below. Table 1 demonstrates the mean values of oven dry density, volumetric shrinkage - swelling and volume-weight values of Eucalyptus wood dried in two different environments obtained from T-tests.

It is obviously seen that the difference drying environment has a significant effect on the properties of eucalyptus wood except for volumetric shrinkage. It was determined that the density and volume weight values of the samples taken from timbers dried in CE were higher than those dried in OE, while the volumetric swelling and shrinkage percentages were lower. Also, it can be seen that the shrinkage percentage values were not significantly affected from differences open-closed environments. Commonly, low swelling and shrinkage values as well as high density in wood material are desirable characteristics (Schulgasser and Witztum, 2015).

Table 1. The T-test analysis results of the findings

Physical properties		Mean	Standard deviation	Standard error	Coefficient of variation	t_{value}	Sig. (2-tailed)
Oven dry density (g/cm^3)	CE	0.737	0.062	0.010	8.41	3.033	0.003
	OE	0.674	0.114	0.018	16.91		
Volume weight value (g/cm^3)	CE	0.63	0.062	0.010	9.84	3.660	0.000
	OE	0.56	0.091	0.014	16.25		
Volumetric shrinkage (%)	CE	10.89	5.224	0.826	47.97	-1.169	0.246
	OE	11.91	1.724	0.273	14.48		
Volumetric swelling (%)	CE	17.14	2.801	0.443	16.34	-2.217	0.030
	OE	18.90	4.153	0.657	21.97		

Under normal conditions, it is known that has more density trees are more shrinkages; but due to the collapse, hysteresis and deformations on the wood, resulting from open-closed drying factors (relative humidity, temperature, etc.), density-shrinkage relationship have not been completely linear. When compared to previous studies, the findings show that the swelling and shrinkage values were consistent with the literature (Unsal et al., 2003; Bal et al., 2012).

As known, in high relative humidity and low temperature conditions, the wood dries more slowly and has more quality and thus less collapse is occurred. The high temperature increases the collapse formation because of reduces the strength of the cell wall (Bozkurt and Goker, 1996). Meanly, the effect of collapse formation on wood stability is mentioned. In our previous study, the cell wall thicknesses of the timber dried in CE (3.98 µm) were found to be significantly different from those dried in OE (3.56 µm), statistically (Bektas et al., 2017). It can also be said that the precipitation and the wind velocity also influential on the results for samples dried in OE. In other words, timbers dried in CE have more dimensional stability than timbers dried in OE.

4. Conclusion

In this study, it has been investigated the effects of different drying environments on the wood dimensional stability properties. The dimensional stability properties of eucalyptus timbers' dried two different environments (open-closed) were determined. The results show that the drying environment has an effect on the dimensional stability of the eucalyptus woods. There were significant differences between oven dry density, volume weight, and volumetric swelling values except for volumetric shrinkage value in different environments. It is thought that this is caused by the severity of drying conditions in OE. Besides, the cell wall thickness of timbers dried in CE was measured higher than that of timbers dried in OE. Consequently, it can be said that drying eucalyptus timbers in CE gives more suitable results.

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