THE EFFECTS OF STEM HEIGHT ON THE PHYSICAL PROPERTIES OF EUROPEAN LARCH (*Larix decidua* Mill.) WOOD

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ABSTRACT

The aim of this study was to determine the effect of stem height on the physical properties of European larch (*Larix decidua* Mill.) wood. The sample trees harvested from Maçka Research Forest in Trabzon. The preparation of small clear specimens and application of test procedures were performed according to Turkish standards. Wood density (oven dry and in 12 % moisture content), basic density, shrinkage and swelling values, were determined for physical properties of wood. Moreover the variation of these properties were determined related to stem height. Consequently, the decreasing trend in the physical properties was observed in direction from bottom to top.

Key words: vertical wood density, stem height, physical properties, European larch

INTRODUCTION

The European larch (*Larix decidua* Mill.) is distributed all over the Alps, the Carpathians, Suderter and in southern and central Poland (Scheepers et al. 2000). *Larix decidua*, being an important timberline species only in the central and western Alps, occurs over a relatively wide altitudinal distance in Europe (Gower and Richards, 1990). It grows to the height of 45 m and produces a straight cylindric stem with a diameter of almost 1 m. It can be worked generally with hand and machine tools. It is utilized as construction material, door and window frames, flooring, boat planking, posts and fencing (Jackson and Day, 1991).

Wood density is one of the most important factors giving an idea about the mechanical properties of wood and use of it. Moreover wood density is one of the most important physical properties of wood and it is associated with other physical properties, and varies depending on ring width, the ratio of earlywood and latewood, the age of tree, the position in stem, site factors, soil type etc. Wood properties also vary both radial and vertical direction of the stem according to species. Many studies have been done especially in conifers on the variation of wood properties along stem. Molteberg and Høibø (2006) found that basic density and fiber length in Norway spruce increased with increasing height in the tree. Antony et al. (2010) found that, in *Pinus taeda*, specific gravity decreased in a nonlinear model with tree height. Wood from the crown in *Pinus radiata* has a lower density because of a decrease in cell wall thickness is reported by Cato et al. (2006). The vertical position did not obviously affect the size of the shrinkage in Grand fir (*Abies grandis*/Douglas/Lindl.), this was found by Lukašek et al. (2012). There are very limited studies regarding the vertical variation in wood properties of angiosperms (Rueda and Williamson 1992; Kord et al. 2010; Izekor et al. 2010; Githiomi and Kariuki 2010). Dimensional changes of wood caused by water adsorption are anisotropic (Leonardon

et al. 2010), and this process is identified as shrinkage and swelling of wood. The swelling of wood with liquids is of essential importance to a wide range of commercial and experimental process (Mantanis et al. 1994), the shrinkage value of wood is essential for quality drying of wood (Lukašek et al. 2012). The different shrinkage values with respect to the position in the stem are found by many researchers (Wang et al. 2008; Yamashita et al. 2009a; Yamashita et al. 2009b; Leonardon et al. 2010; Lukašek et al. 2012).

The objective of this study was to investigate selected physical properties of European larch (*Larix decidua* Mill.) wood and vertical variation of this properties along the tree height.

EXPERIMENTAL METHODS

The study area is a research forestry in Trabzon, Turkey. Altitude of the study area is 1100 m and located on soutwest slope. Trees were randomly selected, taking into consideration stem straightness and absence of decay. Tree diameter was measured at breast height (1,3 m above ground). The diameters, lenghts and ages of the trees are ranging from 23 and 24 m, 20 and 21,5 m, and 38 – 40 years, respectively. The sample discs, which are 10 cm thick, were taken from 6 different tree heights with three meters intervals.

For determining the physical properties small clear specimens were cut 2 cm in the radial and tangential direction, and 3 cm in the longitudinal direction based on Turkish standards. The specimens were placed in a conditioning room at 20 ± 2 ºC temperature and 65 ± 5 % relative humudity in order to reach a moisture content of 12 %. Air-dry and oven-dry densities (D_{m12}, D_{m0},g/cm^3), basic density (D_b, g/cm^3), shrinkage [tangential (β_t, %), radial (β_r, %), longitudinal (β_l, %), volumetric (β_v, %)] and swelling [tangential (α_t, %), radial (α_r, %), longitudinal (α_l, %), volumetric (α_v, %)] were carried out based on Turkish Standards TS 2472 (1976), TS 4083 (1984), TS 4085 (1984), TS 4084 (1984) and TS 4086 (1984).

Statistical analysis was conducted using the SPSS 20.0.0 version. Arithmetic mean and standard deviation of gathered data were determined.

RESULTS AND DISCUSSION

Physical properties

The results of some physical properties are shown in Table 1. Oven-dry density, air-dry density and basic density values of *Larix decidua* were determined as 0,52 g/cm^3, 0,54 g/cm^3, 0,45 g/cm^3, respectively. Wood density is the most important characteristic especially in wood utilization and applications demanding strength. According to study by Bozkurt and Erdin (1990) *Larix decidua* can be classified as 'medium density' wood. Oven-dry and air-dry density values are given in a book prepared by Bozkurt and Erdin (1997) as 0,55 and 0,59 g/cm^3, respectively. Lars et al. (2005) found that mean density values of *Larix decidua* with two different origins were 0,53 and 0,62 g/cm^3, and stated that different origins, annual ring width and latewood proportion affected wood density.

Table 1: Some physical properties of *Larix decidua* (Mill.) wood

	Density (g/cm^3)			Shrinkage (%)				Swelling (%)			
	D_{m0}	D_{m12}	D_b	β_t	β_r	β_l	β_v	α_t	α_r	α_l	α_v
Average	0.521	0.543	0.454	9.34	4.69	0.36	14.38	10.36	4.75	0.73	15.83
Standard deviation	0.039	0.038	0.033	1.36	0.77	0.22	1.90	1.63	0.87	0.26	2.24
Sample size	607	607	708	778	778	778	778	778	778	778	778

As shown in Table 1, the average shrinkage values were found in the tangential direction 9,34 %, radial direction 4,69 %, longitudinal direction 0,36 %. Volumetric shrinkage was calculated as 14,38 %. *Larix decidua* can be classified as 'the high percentage of volumetric shrinkage' wood (Bozkurt and Erdin, 1990). Tangential shrinkage, radial shrinkage and volumetric shrinkage were reported as 7,8 %, 3,3 %, 11,4 %, respectively (Bozkurt and Erdin, 1997).

Variation in physical properties with stem height

The variation of density values along stem height is shown in Figure 1. In the present study a similar trend was observed for density values. Oven-dry density, air-dry density and basic density decreased to 9 m in height and then increased to 15 m in height, and reached the minimum value at 18 m in height. The highest density values were determined at 3 m in height. The reason for wood density is different at diffferent tree heights may be the change in cell structure especially cell wall thickness. It is known that the chemical structure of woody cell walls, microfibril angle significantly affects both density and shrinkage properties of wood. This study shows that density values decrease along the stem. Similar patterns were reported for different species such as *Pinus sylvestris*, *Betula pendula* and *Betula pubescens* (Repola, 2006), *Populus euramericana* (Kord, 2010), *Eucalyptus grandis* (Githiomi and Kariuki, 2010), *Sterculia appendiculata* K. Schum (Ali and UetimaneJunior, 2010), *Tectona grandis* (Izekor et al. 2010), *Pinus taeda* (Antony et al. 2010). On the other hand, Molteberg and Høibø (2006) and Jyske et al. (2008) found increasing wood density with increasing tree height for Norway spruce trees.

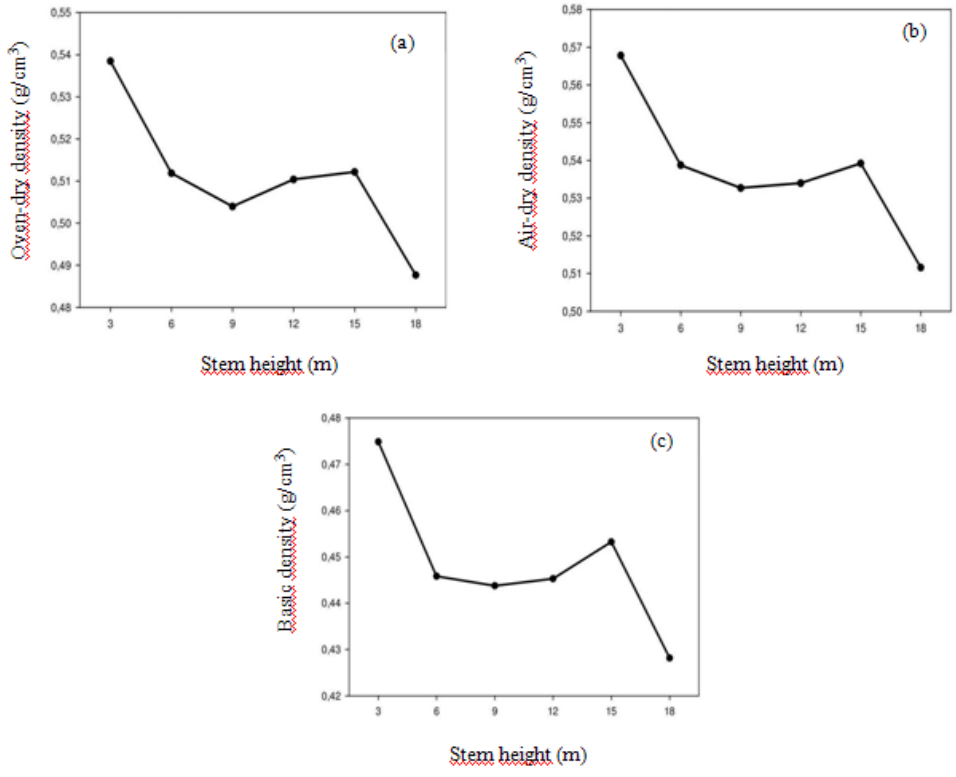

Figure 1: Variation of density values (a, b, c) along the stem height

Figure 2 shows the variation of shrinkage and swelling values along the stem height. The shrinkage and swelling values (tangential and volumetric) initially rise with height, and then drop towards to top. The highest shrinkage and swelling values (tangential and volumetric) are at the height of 9 m. The lowest values belong to the top section of the trunk. The radial shrinkage and swelling values increase slightly in the vertical direction. On the other hand, longitudinal shrinkage and swelling values do not have a clear trend in vertical direction. The top section shows statistically the lowest values for shrinkage and swelling values (tangential and volumetric). Wang et al. (2008) found that the longitudinal shrinkage of *Pinus radiata* showed a trend of decrease with the stem height, but tangential and radial shrinkage did not show a clear trend. Differenttrends were found among the five cultivars of sugi (*Cryptomeria japonica*) in relation to longitudinal shrinkage (Yamashita et al. 2009a) and tangential and radial shrinkage (Yamashita et al. 2009b). Lukašek et al. (2012) reported that the vertical position did not clearly influence the size of shrinkage of Grand fir. Furthermore, Chowdhury et al. (2007) found that, in 25 years old Jhau (*Casuarina equisetifolia*), radial and longitudinal shrinkages did not vary with increasing tree height, but tangential shrinkage did vary.

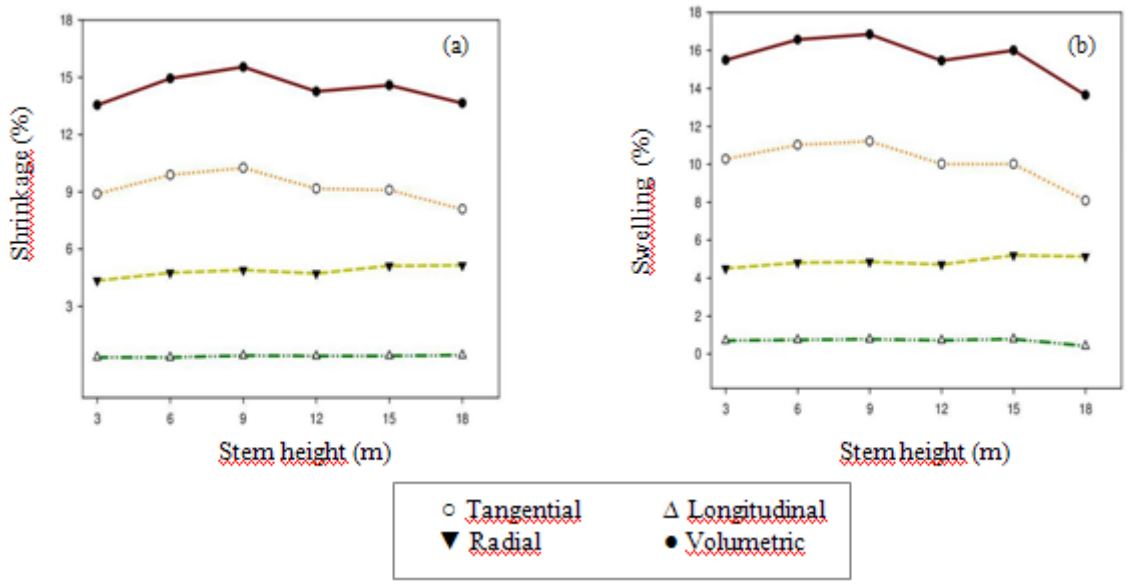

Figure 2: Variation of shrinkage (a) and swelling (b) values along the stem height

CONCLUSIONS

The conclusions of this study are as follows:

- In this study the average values of wood density, volumetric shrinkage and volumetric swelling of *Larix decidua* were determined 0,54 g/cm^3, 14,38 %, 15,83 %, respectively. Although *Larix decidua* is a tree species that has medium density, the shrinkage and swelling values of its wood are high. Necessary measures should be taken especially in utilization in weather conditions.
- There was a general trend in vertical direction in *Larix decidua* trees, in which wood density, shrinkage and swelling (tangential and volumetric) decreased, along the stem height.

- Because wood density affects mechanical properties of wood, the utilization of *Larix decidua* wood may be determined in related to stem height.
- While the variation of wood density and other wood properties are studied within a tree, the ring width and ultramicroscopic structure of wood should also be investigated.

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