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The Effect of Heat Treatment on Some Mechanical Properties and Color Changes of Uludag Fir Wood

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In this study, the effects of heat treatment on color, mass loss, compression strength, and hardness of Uludag fir (*Abies bornmulleriana* Mattf.) were investigated. Wood specimens conditioned at a relative humidity of 65% and a temperature of 20°C were subjected to heat treatment at 170, 190, and 210°C for 4, 8, and 12 h. After heat treatment, compression strength and hardness were determined according to TS 2595 and TS 2479. Color changes were determined according to DIN5033. The results showed that compression strength and hardness of Uludag fir wood decreased to varying extents in relation to intensity of treatment, whereas mass loss increased. We determined that treatment temperature had a more significant effect on color changes than did treatment time. The color of the wood became darker at the higher treatment temperatures.

Keywords Color changes; Hardness; Heat treatment; Mass loss; Uludag fir

INTRODUCTION

Since ancient times, wood has been used for manufacturing various materials used in daily life. In the last century, the development of new technologies, such as plastics, has led to a decrease in the development of wood technologies even though, unlike plastic, wood is a biologically sustainable material. When wood is used to make various products, its hydroscopic characteristic can cause problems due to changes in moisture content that result in anisotropic swelling and shrinkage. However, various chemicals can be used to prevent these disadvantages. Today, researchers in many countries are trying to find alternatives to the use of these chemicals for treating wood, because the chemicals such as creosote and chromated copper arsenate (CCA) are harmful to the environment. One alternative is to use heat treatment instead of chemical modification. There are many different methods of heat treatment already in use throughout the world; e.g., the Plato method used in The Netherlands, the ratification and perdure methods used in France, oil heat treatment (OHT) used in Germany, and the ThermoWood method used in Finland.[1]

The wood species Uludag fir used in this study is an endemic species in Turkey. Uludag fir trees grow up to 40 m tall, and they are classified as a first-class forest tree. Their natural habitat, which is in the western Black Sea region in Turkey, has spread from the Kizilirmak delta to the Uludag Mountain and Kocaeli vicinity.[2] The most important factor in heat treatment is the temperature at which it is conducted. Even so, other variables, such as heat treatment duration, ambient air pressure, the distribution of moisture and temperature, and the species of wood affect the properties of the resultant product.[3–5] It is generally accepted that during high-temperature treatment, hemicellulose degrades more than other macromolecular compounds.[6] The dehydration reaction, which is called the *building block*, begins at 140°C. The OH content then starts to decrease, which is considered to be much more important than dehydration. In addition, CO and CO_2 are found in the off-gases during heat treatment.[7]

The loss of mass during heat treatment is considered to be attributable to water loss in the wood structure as a result of the decreasing availability of OH groups, the loss of materials in the cell wall, and the disintegration of hemicelluloses.[8] These studies analyzed the heat treatment of Uludag fir at temperatures of 170, 190, and 210°C for treatment durations of 4, 8, and 12 h. Results of the studies showed that the equilibrium moisture content of heat-treated samples was 50% lower than the moisture content of untreated control specimens. It was determined that, after treatment temperature, the duration of heat treatment was the second most important factor affecting the equilibrium moisture content.[9–12]

Mitsui[13] observed a color change after beech (*Fagus sylvatica*) wood specimens were subjected to heat treatment and the application of light. After heat treatment, L^*, a^*, and b^* color coordinate values decreased. After the application of light, L^*, a^*, and b^* values decreased further, but the b^* values decreased significantly more than did the L^* and a^* values. According to Inoue et al.'s[14] study of Sugi (*Cryptomeria japonica* D. Don), in which wood

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