



University of Zabol  
Graduate school  
Faculty of Natural resource  
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**The Thesis Submitted for obtaining a doctorate degree (in the field of wood industry-lignocellulosic composites)**

# **Improving the efficiency of the multi-layered board made of date palm by thermal and chemical modification**

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## **Abstract**

Thermal modification in the temperature range of 140 to 160 oc led to an increase in density to  $0.68 \text{ gr/cm}^3$  in date palm tissue. The lowest density is obtained at the heat treatment temperature of  $210 \text{ }^\circ\text{C}$  with an average of 0.49 grams per square centimeter. The density of the date palm control sample was determined to be  $0.63 \text{ gr/cm}^3$ . The static bending moment (MOR) of unmodified (control) date palm samples was obtained with an average of  $39.1094 \text{ kg/cm}^2$ . Meanwhile, the average value of date palm samples after thermal modification was recorded as 70.719. In this research, the highest modulus of elasticity is related to thermal modification at  $160^\circ\text{C}$ . The average MOE for unmodified samples was determined as  $4712.76 \text{ kg/cm}^2$ . Meanwhile, the average MOE for modified samples was calculated as  $5355.14 \text{ kg/cm}^2$ . This result means that changes have been made in the date palm tissue after thermal modification. The results of the investigation of the resistance against the perpendicular tension of the fibers of low number were recorded. The measured value of this test was determined with an average of  $6.70 \text{ kg/cm}^2$  centimeter. Regarding the thickness of the date palm coating, the best sample was determined to be 3 mm of date palm coating both without modification and with

modification. As a result of thermal modification of date palm and multi-layered board, the resistance of palm tissue and the holding power of nails increased to some extent. Examination of the anatomy of palm tissue in the 160 °C corrective treatment showed that after the heat treatment, black spots were created in the vascular cavities and the tissue cracked. This modification leads to small changes in the morphological structure. In this research, the highest modulus of elasticity is related to thermal modification at 160°C. The average MOE for unmodified samples was determined as 4712.76 kg/cm<sup>2</sup>. Meanwhile, the average MOE for modified samples was calculated as 5355.14 kg/cm<sup>2</sup>. This result means that changes have been made in the date palm tissue after thermal modification. The results of the investigation of the resistance against the perpendicular tension of the fibers of low number were recorded. The measured value of this test was determined with an average of 6.70 kg/cm<sup>2</sup> centimeter. Regarding the thickness of the date palm coating, the best sample was determined to be 3 mm of date palm coating both without modification and with modification. As a result of thermal modification of date palm and multi-layered board, the resistance of palm tissue and the holding power of nails increased to some extent. Examination of the anatomy of palm tissue in the 160 °C corrective treatment showed that after the heat treatment, black spots were created in the vascular cavities and the tissue cracked. This modification leads to small changes in the morphological structure. During the heat modification operation, almost clear smoke, aromatic and special smell was created due to the evaporation of extractive materials such as waxes, sugars and fats in the palm. The release of this phenomenon is considered one of the results of thermal modification. This process could be seen and felt during the thermal modification in the laboratory environment. In the chemical analysis of date palm after and before modification in the FT-IR spectrum analysis section, the results indicated that the lowest amount of lignin degradation occurred at the temperature of 160 °c respectively. On the other hand, the changes that occur after the heat treatment of date palm show the reaction and increase of lignin. In this research, three different seat designs were used. The maximum applied force for the first type chair without thermal modification and the control sample force was determined as 834, 1794, 1862 respectively. But for the thermally modified seat, the maximum force recorded from top to bottom for the fully curved one modified with heat was determined to be 2065 newtons. Therefore, the strength of the seats with the curved frame of the modified palm date plywood (LVL) is improved. Thermal modification of palm tissue improves its functional characteristics and can be called as an environmentally friendly modification method to make palm usable in the furniture industry.