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Effect of Almond Shell Particles on Tensile Property of Particleboard

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Abstract
The purpose of present study was to fabricate particleboard using almond shell. This might help to overcome the raw material shortage that the panel industry is facing now days. Particleboards containing different almond shell particle ratios were made using epoxy resin. Tensile properties of almond shell particleboards were determined in this research paper. The addition of almond shell particles greatly affected the tensile property of the panels. Hardness is very important property for the particle board. In the present, investigation tensile strength of fabricated particle board decreases with increase in the almond shell particles.

Keywords: Almond shell, Resin, Particleboard, Mechanical properties.

1. Introduction
Forests are declining at the alarming rate of 13.0 million hectare each year in developing countries [1]. The production of particleboard has been constantly increasing due to its several advantages compared to solid wood and other composite materials. The use of agricultural residues in particleboard production is preferred because of economical and environmental concerns. The use of agricultural residues as an industrial raw material has been practiced in panel industry for years. These days panels made of bagasse, wheat and other crop residues are being commercially manufactured in a number of countries to avoid the high consumption of wood [2]. Among these, some studies evaluated the feasibility of biomass for particleboard manufacturing like hazelnut husk [3], peanut hull [4], pine cone [5] and almond shell [6]. Agricultural residues will play an important role in the safeguarding future of the forest industry [4]. Almond (Prunus amygdalus L.) is an important crop throughout the world's temperate regions [7]. Almond shell, an agricultural residue, is the ligno-cellulosic material forming the thick endocarp or husk of the almond fruit that upon processing to obtain the edible seeds is separated and having no important industrial usages are normally incinerated or dumped [8]. Burning agricultural residues causes environmental problems such as air pollution, soil erosion and decreases soil biological activity [3]. Utilizing agricultural residues not only prevents environmental concerns but also can mean farmers second income [3, 9]. The raw material demand from the forest industry has continued to grow at a high rate. This problem along with the necessity of conserving natural resources have led to great efforts regarding the use of agricultural residues in particleboard manufacturing [2,4,10]. Therefore the aim of this study was to investigate the suitability of almond shell particles in production of particleboard as supplement and to alleviate the shortage of raw material in forest industry and study was carried out to determine the effects of almond shell particles on tensile strength of composite particleboard produced from almond shell.

2. Materials and methods

The almond shell used in the present investigation was arranged from local market. The collected almond shell, shown in figure 1, were dried in sun for a day and subsequently cut into small pieces. It was then ground in a Wiley mill to convert into small particles as shown in figure 2. Particle size is maintained by sieving in between ASTM 40 and ASTM 80 number of sieve. Epoxy resin (CY230), hardener (HY951) and almond shell particles with different weight percentage were used. Different weight percentage (wt%) of almond shell particles (10, 15, 20, 25, 30 wt%) and epoxy resin were mixed by mechanical stirring at 3000 rpm.

Fig. 1: Almond shell

Fig. 2: Wiley mill

The solution obtained by mixing of almond shell particles in resin was kept in the furnace at a temperature of 90 ± 10 °C for two hours. At each interval of 30 minutes the solution was taken out from the electric furnace and remixed by mechanical stirrer at same speed. After two hours the whole solution was taken out and allowed to cool to a temperature of 45°C. When a temperature of 45°C had been attained the hardener HY951 (10 weight per cent) was mixed immediately. Due to addition of hardener, high viscous solution thus obtained was remixed mechanically at high speed by the mechanical stirrer [2]. The viscous solution so obtained was poured into different moulds of size 46mm×46mm×10mm for sample preparation. Tensile tests were conducted on 100 kN servo hydraulic universal testing machine (ADMET, USA) under displacement mode of control of 1mm/min. The results are presented and discussed in subsequent sections.

3. Results and discussion

Tensile strength

The mechanical properties of the almond shell particles filled composite material was determined by 100 kN ADMET make servo controlled universal testing machine at 1mm/min crosshead speed under displacement control mode as shown in figure 3.

The properties of different percentage of almond shell particles along with that of epoxy resin are presented in table 1. The results of modulus of elasticity and ultimate tensile strength are shown in the table 1 for strain rate of 1mm/min. Remarkable differences can be seen on the ultimate tensile strength of the composite material having different wt% of almond shell particles. It can be noticed that for all tested material, the ultimate tensile strength is lowest for the 30 wt% almond shell particle composite and is 26.24 MPa. When almond shell particle is decreased to 10 wt%, the value of the ultimate strength goes up and it is 37.27 MPa. The decrease of ultimate strength due to increase in almond shell particle content is because of pure binding with the epoxy and voids present in the material.

Fig. 3: Universal Testing Machine

Table 1: Tensile properties of the almond shell particles based composite materials.

Property	10% almond shell particles	15% almond shell particles	20% almond shell particles	25% almond shell particles	30% almond shell particles
Modulus of elasticity, E (MPa)	1652	1601	1532	1396	1288
Ultimate stress (MPa)	37.27	33.57	31.28	28.94	26.24

Remarkable differences can be seen in the behaviour of mechanical properties due to addition of different wt% of almond shell particles in epoxy resin as shown in figure 4.

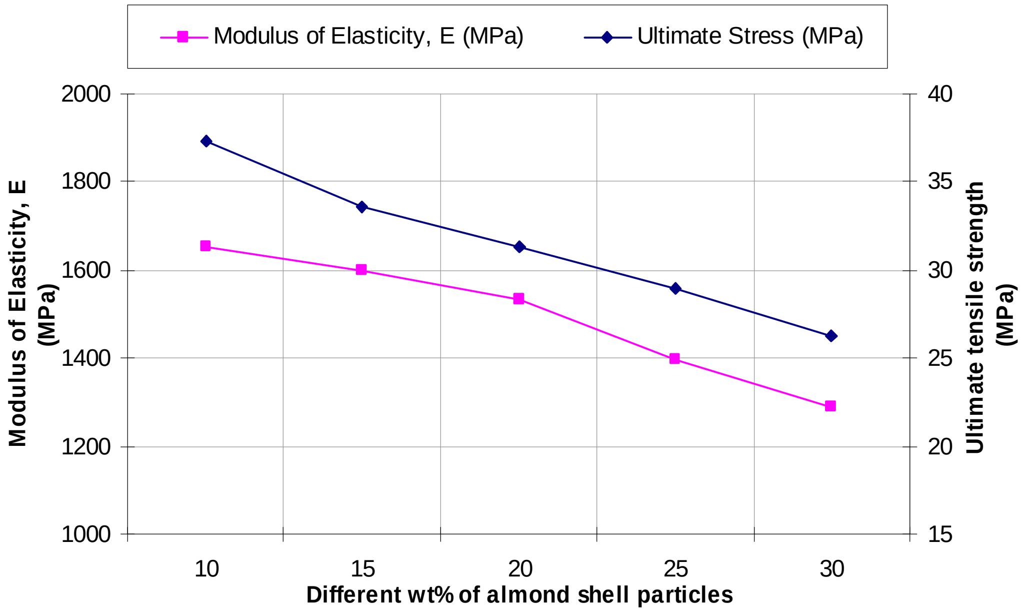

Fig. 4: Effect of different wt% of almond shell particles on ultimate tensile strength and modulus of elasticity.

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On the basis of results obtained the effect of weight fraction (V_f) on modulus of elasticity and ultimate strength are shown in equation 1 and 2 with a correlation coefficient greater than 0.99:

$$\text{Modulus of Elasticity (MPa)} = -12.929\, V_f^2 - 15.729\, V_f + 1683.2 \quad (1)$$
$$\text{Ultimate Strength (MPa)} = 0.1393\, V_f^2 - 3.5047\, V_f + 40.442 \quad (2)$$

4. Conclusions

This study investigated the suitability of almond shell particles in the production of particleboard. Addition of almond shell particles highly influenced the mechanical properties of the particleboard. The modulus of elasticity decreases as the wt% of almond particle is increased. It is minimum for 30% almond shell particle concentration. Addition of almond particles also decreases the ultimate tensile stress with addition of almond particles. Use of almond shell in particleboard production not only saves forest but may also result in several environmental and socioeconomic benefits.

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