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Physical and Mechanical Properties of Kenaf (*Hibiscus cannabinus*) MDF

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ABSTRACT
This study was under taken to identify the physical and mechanical properties of kenaf (*Hibiscus cannabinus*) MDF and to evaluate the potential of kenaf MDF in Bangladesh. Properties were compared with market MDF in Bangladesh. Physical and mechanical properties were examined. The density of kenaf MDF and market MDF were respectively, 0.73 and 0.72 g cm^{-3}. The MOR of kenaf and market MDF was 44.97 and 40.65 N mm^{-2}, respectively. The MOE for kenaf and market MDF was 3786 and 3518 N mm^{-2}, respectively. The physical and mechanical properties of kenaf MDF were better than market MDF. The kenaf MDF followed the standard and it can be a good source of raw material for MDF industries.

Key words: *Hibiscus cannabinus*, physical properties, mechanical properties, modulus of rupture (MOR), modulus of elasticity (MOE)

INTRODUCTION
Wood or other lignocellulose fibers are bonded by synthetic or other suitable adhesives under heat and pressure to produce a fibrous felted and homogeneous panel named Medium density fiberboard (MDF) (NPA., 1994). Its numerous advantages over solid wood and other composite materials enhance the production of fiberboard. Most end-use requirements are meeting by uniform fiber distribution of fiberboards in their structure. It can easily be machined and finished for various purposes i.e., furniture production. The surface smoothness of MDF provides an excellent substrate for paint and decorative overlays and this helps to use it as the best material for cabinet manufacturing (Copur *et al*., 2008).

The forest products i.e., MDF, plywood and lumber offer different types of advantages over solid wood products. The demand of forest products is increasing considering the benefits of them. Aggressive deforestation is going on in the world due to increase the demand of forest products (Copur *et al*., 2008; Youngquist *et al*., 1993; Adger and Brown, 1994). Utilization of agricultural residues as alternative raw materials can resolve this type of problem partially with offering numerous economic, environmental and technological advantages. These are plentiful, renewable and widespread. Using them in the industry is one type of environmental friendly practice as well (Akgul *et al*., 2010).

The suitability of agricultural residues as raw materials of wood industry has been examined conducting several studies to overcome the shortage of wood. Considering the utilization of non-wood plants in the forest based industry, some researchers provide accounts of world-wide research (Alma *et al.*, 2005; Youngquist *et al.*, 1993; Youngquist *et al.*, 1994). The suitability of production of composites using of wheat straw, cotton stalk, sun flower stalk and husk was examined by some researchers Eroglu *et al.* (2000), Gencer *et al.* (2001), Guler and Ozen (2004), Bektas *et al.* (2005) and Copur *et al.* (2008). Rowell and Harrison (1993) prepared kenaf fiberboard. Kenaf core binder less fiberboard was prepared in previous study by Xu *et al.* (2006) and kenaf fiber polypropylene was made by Sanadi *et al.* (2002). In this study, it was tried to identify the physical and mechanical properties of kenaf MDF using urea formaldehyde as a binding agent.

MATERIALS AND METHODS

The kenaf stick used in the study was grown in the Laboratory Field of Agrotechnology Discipline, Khulna University (22°48'0"N and 89°33'0"E), Khulna, Bangladesh. The sticks were dried in sunlight and the bast fiber was separated from the stick. The core part of kenaf stick was chipped into 2.5 cm in length to get fiber for preparing board.

Semi chemical pulping was followed to separate the fiber. The chips were submerged in 19% sodium hydroxide (NaOH) solution for 24 h and in the next the chips were washed properly to make them free from NaOH. Deliberation of washed chips was then done using one 25 cm single disc laboratory atmospheric refiner and the refined fibers were dried in the air. Next these were dried in an oven at 103°C to reduce moisture content at 4% and dried fibers were kept in sealed plastic bags until used.

In this study, urea formaldehyde was 20% on the dry weight basis as a binding agent for the board. A blender was used to mix adhesive with fiber uniformly. Then mat was formed on a steel sheet using an iron frame. The mat was pressed in a hot press for 60 min at 0.8 N mm^{-2} pressure but the coil of hot press was switched on for the first 30 min. The temperature was 125°C for the board. The board was trimmed to their final dimensions of 30×30 cm after cooling and stored at room temperature. The thickness was 0.30 cm. Market MDF was collected from local market, Khulna, Bangladesh.

The laboratory tests of physical properties for both types of board were carried out in the Wood Technology Laboratory, Forestry and Wood Technology Discipline, Khulna University, Khulna, Bangladesh and the laboratory tests of mechanical properties were done in the Laboratory of Mechanical Engineering Department, Khulna University of Engineering and Technology, Khulna, Bangladesh. ASTM D 1037-100 (ASTM., 2006) and DIN 52362 (DIN., 1984) standard procedures were followed to determine the physical and mechanical properties, respectively.

Microsoft Office Excel 2013 and SPSS (Statistical Package of Social Survey) 11.5 software were used for analyzing all the data obtained during the laboratory tests for characterization of physical and mechanical properties of each type of fiberboards. The analysis was done at 95% level of significance.

RESULTS AND DISCUSSION

Physical properties: The density of kenaf and market MDF was 0.73 and 0.72 g cm^{-3}, respectively (Fig. 1). The density was higher for kenaf comparing to market MDF. Statistical analysis also showed the significant difference (95% level of significance) between the two types of board.

The water absorption was found 34.50 and 40.12%, respectively for kenaf and market MDF (Fig. 2). The water absorption was the lowest for kenaf MDF but market MDF showed the highest value of water absorption. There was significant difference (95% level of significance) between the

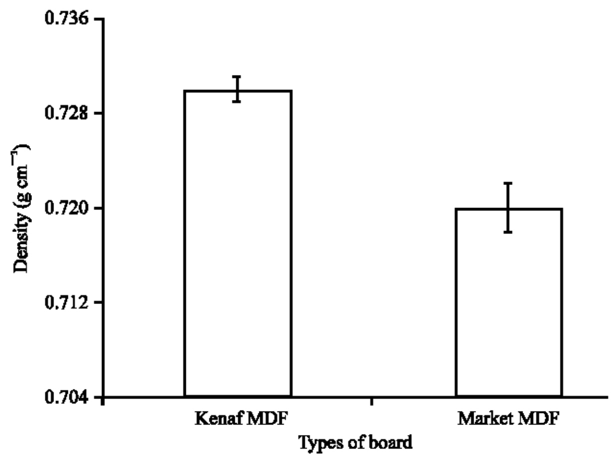

Fig. 1: Density of kenaf and market MDF

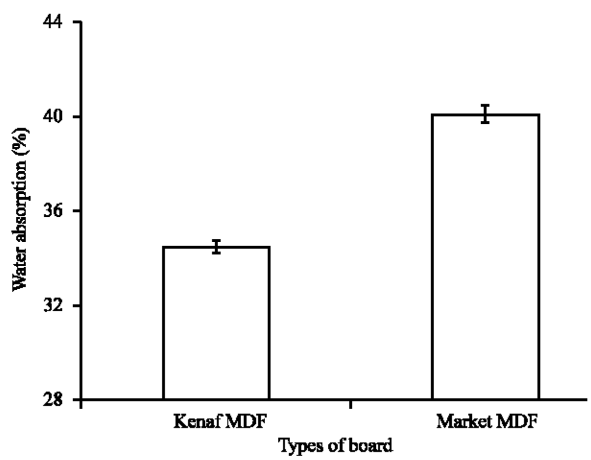

Fig. 2: Water absorption of kenaf and market MDF

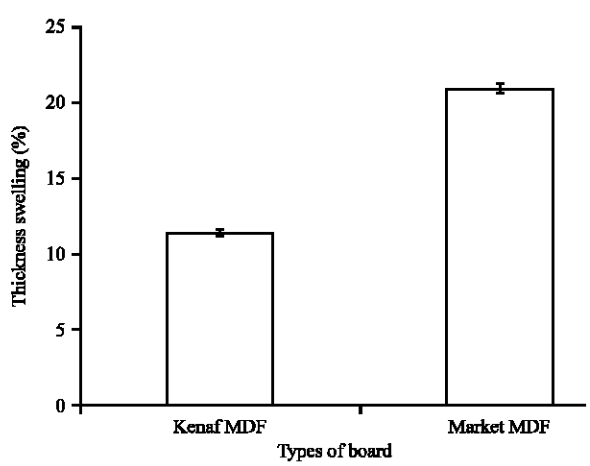

Fig. 3: Thickness swelling of kenaf and market MDF

water absorption of two types of board. This is lower compare to bagasse MDF (76.40%) (Zare-Hosseinabadi *et al*., 2008). Lower water absorption helps to use in adverse condition. Lower water absorption of market and other agricultural residue i.e., bagasse MDF may help to increase the applicability of kenaf MDF for different purposes.

The thickness swelling of kenaf MDF was 11.45% and it was 20.97% for market MDF (Fig. 3). Market MDF showed the highest value of thickness swelling whether it was the lowest for kenaf MDF. The difference of thickness swelling was significant (95% level of significance) between the two types of board. It was 31.90 and 40.50%, respectively for bagasse and wheat straw MDF (Zare-Hosseinabadi *et al*., 2008; Markessini *et al*., 1997). In this study, thickness swelling was lower than previous studies (Zare-Hosseinabadi *et al*., 2008; Markessini *et al*., 1997). Less thickness swelling is also important for using different purposes. Thickness swelling of kenaf MDF is around two times lower than market MDF. It is around three times and four times are lower than bagasse and wheat straw MDF, respectively.

Mechanical properties: The Modulus Of Rupture (MOR) of kenaf and market MDF was 44.97 and 40.65 N mm^{-2}, respectively (Fig. 4). The MOR was the highest for kenaf MDF whether it was

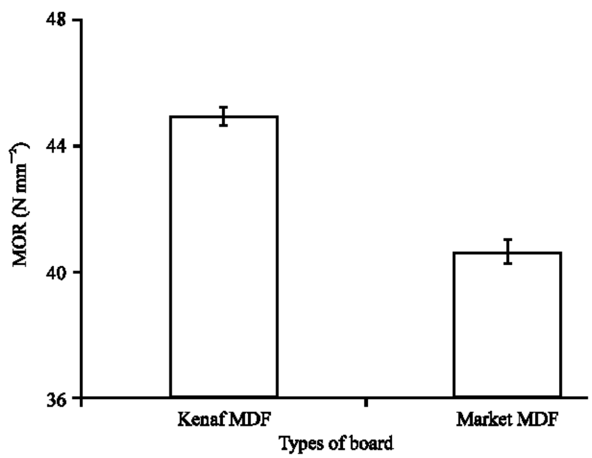

Fig. 4: MOR of kenaf and market MDF

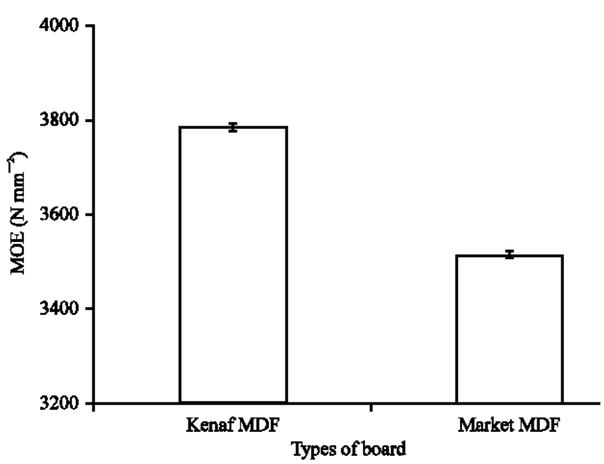

Fig. 5: MOE of kenaf and market MDF

the lowest for market MDF. It was significantly different (95% level of significance) from each other. The MOR increases with the increasing of density. This trend founds in previous study (Xie *et al.*, 2011). According to ANSI (NPA., 1994), the MOR is 34.5 N mm^{-2} as well as according to Desch and Dinwoodie (1996), the standard MOR is 30 N mm^{-2}. The MOR of the two types of board was higher than that of both standards. The MOR of wheat, straw and flax MDF were 18.70, 6.00 and 11.30 N mm^{-2}, respectively (Markessini *et al.*, 1997). The MOR of kenaf MDF followed the standard. It is also higher than standard and previous investigations on MDF made from other agricultural residues.

The Modulus Of Elasticity (MOE) was 3786 and 3518 N mm^{-2} for kenaf and market MDF, respectively (Fig. 5). The MOE was the lowest for market MDF but it was the highest for kenaf MDF. Statistical analysis showed that there was significant difference (95% level of significance) between the MOE of two types of board. Density influences the MOE and it increases with the increasing of density (Xie *et al.*, 2011). According to ANSI (NPA., 1994) and Desch and Dinwoodie (1996), the standard MOE is 3450 and 2500 N mm^{-2}. The MOE of two types follow the both standards and it was higher than that of standards. MOE of Kenaf MDF was higher than MOE of market MDF.

CONCLUSION

The kenaf MDF showed better performance for both cases i.e., physical and mechanical properties than market MDF. It followed the standard and showed higher value than that. The properties of kenaf MDF were also higher than some other MDF made from agricultural residues. These show that there is a possibility to use kenaf as an alternative raw material for MDF industries.

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