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Feasibility study of brown mustard (*Brassica juncea* (l.) Czern) plant as a raw material for manufacturing of particle board

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Abstract
Particle board is mostly used as alternative to wood at present age to reduce the pressure on solid wood. Different raw materials, mostly woody and non woody materials are used as wood particle and various resins are used as binder. Now-a-days, vegetable wastages are also utilized. This study was conducted to compare the feasibility of using Brown Mustard **(***Brassica juncea* (L.) Czern**)** plant wastage for manufacturing of particleboard. The physical and mechanical properties of brown mustard board were tested to access its quality. The particle board made from brown mustard waste presents good physical and mechanical properties. It was found that the density of brown mustard particleboard was 0.836gm/cm^3, moisture content was 6.95%, water absorption was 37.69 %, thickness swelling was 14.58 %, linear expansion was 0.96%, Modulus of Rupture was 26.39 N/mm^2 and Modulus of Elasticity was2795.64 N/mm^2. The physical and the mechanical properties of particle board of brown mustardwaste were compared with the properties of market particle boards. Therefore, it can be concluded that brown mustard wastage can be used as alternative raw material for particleboard manufacturing.

Keywords: Particle board, Urea Formaldehyde, *Brassica juncea* (L.) Czern, Physical properties, Mechanical properties

1. Introduction

Wood is considered as the most precious and abundant renewable natural resources of the world. Wood had been used for thousands of years before observing any specific knowledge of its physical and mechanical properties. It was used as the first source of energy by mankind. Wood is considered as the only affordable and domestically available source of energy in most developing countries where more than two billion people directly dependent this resource for cooking and/or heating. Cooking and heating of private household with the use of wood fuels holds one-third of total global renewable energy consumption that makes wood as the most decentralized source of energy of the world (FAO, 2010c). According to a study of 2020, wood and wood wastage resulted in about 5.5% industrial end-use energy consumption and 4.4% of total industrial energy consumption.

On the other hand, particle boards can also be prepared from wood and other non wood materials other than using only as fuel consumption. Particleboard is a composition of cellulosic particles of various sizes bonded together with synthetic resin or binder in presence of stipulated heat and pressure that forms composite panel products. Maximum particle size of a particle board is 3mm and having an average particle size of between 0.2mm and 2.00 mm. The wood particles are combined with glue, present in a concentration of 5% to 18% by weight, and 0.1% to 1% by weight of a sizing agent. The particle board components are subjected to a pressure of 15 to 50 kp/cm² and a temperature of 120° to 210°C to produce a particle board having a density of 600 to 1200 kg/m³ and water absorption of 14% to 30% by weight (Larsson *et* 53 *al*., 1997)

2. Materials and Methods

Brown Mustard (*Brassica juncea* (L.) Czern) plant wastage was obtained locally. The raw materials for particleboard manufacturing were collected from Satkhira, the southern district of Bangladesh. The dried plant of brown mustard was collected and stored. In order to make the raw material more brittle, it was then dried under sunlight for few days. This dried raw material was manually chipped by the use of a sharp chopper to reduce the size to a usable limit. The chips were then fed into laboratory grinder to produce desired particle. The size was controlled by the use of a mesh opening at 1.5 mm. The grinded particles were then mixed uniformly in order to ensure better performance that is followed by removing the dust by using a net. After that, the raw materials were dried in an electrically heated lab scale oven at 80±3°C for 24 hours. After mixing and drying of the particles, it was blended manually with Urea Formaldehyde (UF) resin in a drum type blender. Based on the weight of dry resin solids and oven dry weight of the particles, the resin content of particle board can range between 4% and 10% which ranges between 6% and 9% in case of Urea Formaldehyde resins (Youngquist, 1999). Here, 9% Urea Formaldehyde was mixed with raw materials. Mat for particle board production was formed on a steel sheet in laboratory. Then, mat was pressed on a computer controlled hot press under temperature at 150° C and 5MPa pressure for 12 minutes. The temperature switch was switched off after 12 minutes. Hot-press temperatures for thermosetting materials (e.g. UF, PF) usually range from 140°C to 165°C (284°F to 325°F). (Youngquist,1999). This process of particleboard manufacturing is called flat-press process (AWPA, 2001 and Youngquist, 1999).

After stopping temperature the board was remained fixed for cooling for another 22 minutes. The hot board was removed from the press and further conditioned to equilibrate board moisture content and to stabilize and fully cure the adhesives (AWPA, 2001). This was followed by trimming of edges to have desired length and width. Trim losses usually amount to 0.5% to 8%, depending on the size of the board, the process employed, and the control exercised (Youngquist, 1999). Sanding was done to smooth the surfaces.

The particle board was manufactured at Laboratory of Pulp and Paper Technology and Wood Composite and Wood Laboratory that are controlled by Forestry and Wood Technology Discipline, Khulna University, Khulna. All tests for its quality (except MOE and MOR) were also done there. The laboratory tests for characterization of physical properties and mechanical properties for each type of particleboards were carried out respectively in the Wood Technology Laboratory of Forestry and Wood Technology Discipline of Khulna University and in the Laboratory of Civil Engineering Department of Khulna University of Engineering and Technology, Khulna. The properties were tested according to the procedures defined in the American standard for particleboards (ANSI A208.1–1993) (NPA, 1993) as well as the Indian standard for particleboards (IS: 3087- 1985).

The dimension of samples for testing the physical and mechanical properties were approximately (50 mm × 35 mm × 6 mm) and (160 mm × 35 mm × 6 mm) respectively.

3. Results and Discussion

3.1 Physical properties

3.1.1 Density of the board

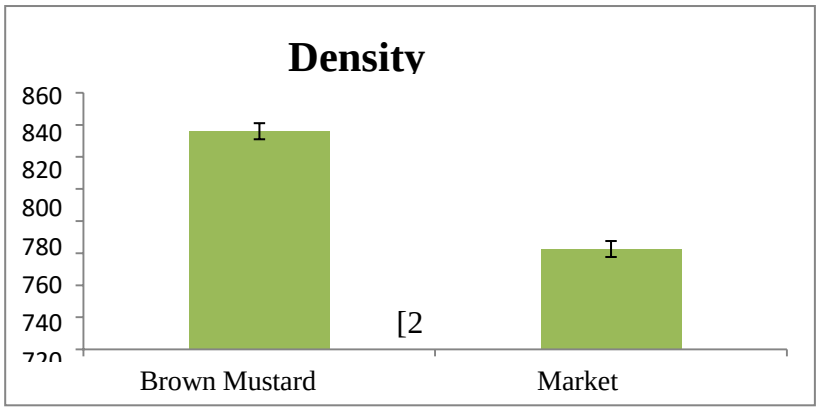

Fig 1. Density of Brown Mustard particleboard and local market particleboard

It was found that the density of Brown Mustard particleboards was 836.03 kg/m^3 and market particleboard was 762.55 kg/m^3 respectively. From the t-test, it was found that there was no significant difference (t=4.090, df=5 and P>0.05) of density between brown mustard particle board and market particle board. According to IS specification 3087, the density of standard particleboard is 500-900 kg/m^3 and according to German standard Din 68761 (Verkor 1975), particleboard standard is 590-750 kg/m^3.

3.1.2 Moisture content after curing

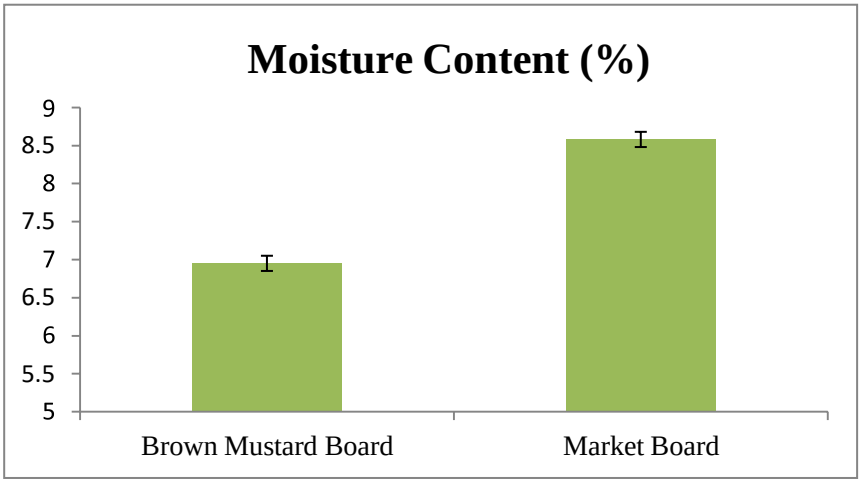

Fig 2. Moisture Content % after curing in Brown Mustard particleboard and local market particleboard

After curing, the moisture content was 6.95% for Brown Mustard particleboard and 8.58% for market particleboard. From the t-test, it was found that there was significant difference (t=-4.696, df=5 and P<0.05) of moisture content between brown mustard particle board and market particle board. The maximum moisture content in the standard particleboard was not found as per ANSI A208.1–1993 (NPA, 1993) and IS: 3087-1985 as well as British Standard BS: 5669 and German Standard DIN 68 761 (Verkor and Leduge, 1975). But according to Australian and Newzealand Standard (AS/NZS 1859.1: 2001.Int), the moisture content of standard particleboard is 5-8% (for 18 mm thick board) (The Laminex Group, 2003).

3.1.3 Water absorption

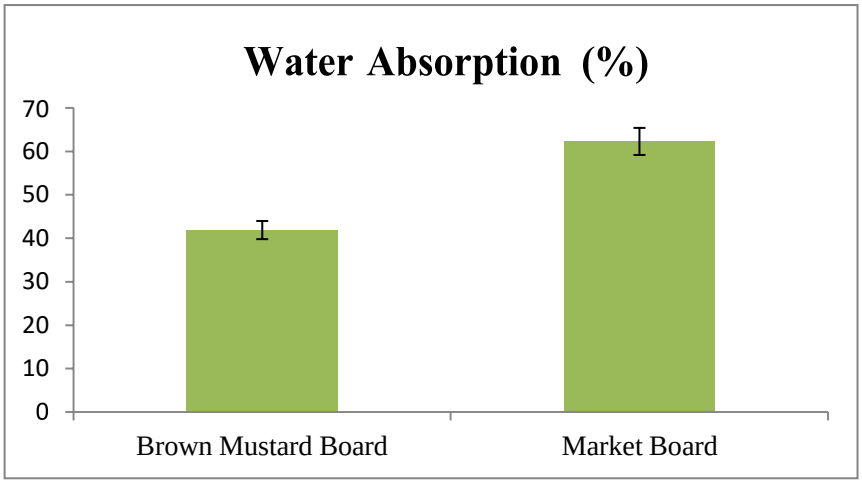

Fig 3. Absorption of water by Brown Mustard particleboard and local marketparticleboard after 24 hours soaking

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It was found that after 24 hours the percentages of water absorption was 41.86 % in Brown Mustard particleboard and 62.25% in market particleboard. From the t-test, it was found that there was significant difference (t=-4.721, df=5 and P<0.05) of water absorption between brown mustard particle board

and market particle board. According to IS specification 3087 the absorption of water by standard particleboard is 50% after 24 hours soaking. The water absorption percentage by standard particleboard was not found as per ANSI A208.1–1993 (NPA, 1993) as well as Australian and Newzealand Standard (AS/NZS 1859.1: 2001.Int) (The Laminex Group, 2003), British Standard BS: 5669 and German Standard DIN 68 761 (Verkor and Leduge, 1975).

3.1.4 Thickness swelling

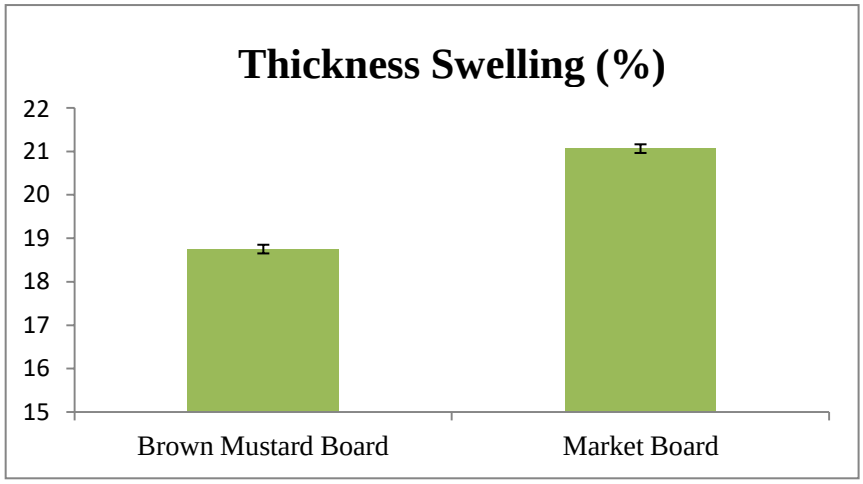

Fig 4. Thickness swelling of Brown Mustard particleboard and local market particleboard after 24 hours soaking

It was found that after 24 hours the percentage of Thickness swelling was 18.75% in Brown Mustard particleboard and 21.06% in market particleboard. From the t-test, it was found that there was significant difference (t=-3.486, df=5 and P<0.05) of thickness swelling between brown mustard particle board and market particle board. The thickness swelling percentage after 24 hours immersion in water by standard particleboard was not found as per ANSI A208.1–1993 (NPA, 1993) and IS: 3087-1985 as well as British Standard BS: 5669 and German Standard DIN 68 761 (Verkor and Leduge, 1975). But according to Australian and Newzealand Standard (AS/NZS 1859.1: 2001.Int), the thickness swelling of standard particleboard is 15 % after 24 hours immersion in water for 18 mm thick board (The Laminex Group, 2003).

3.1.5 Linear Expansion

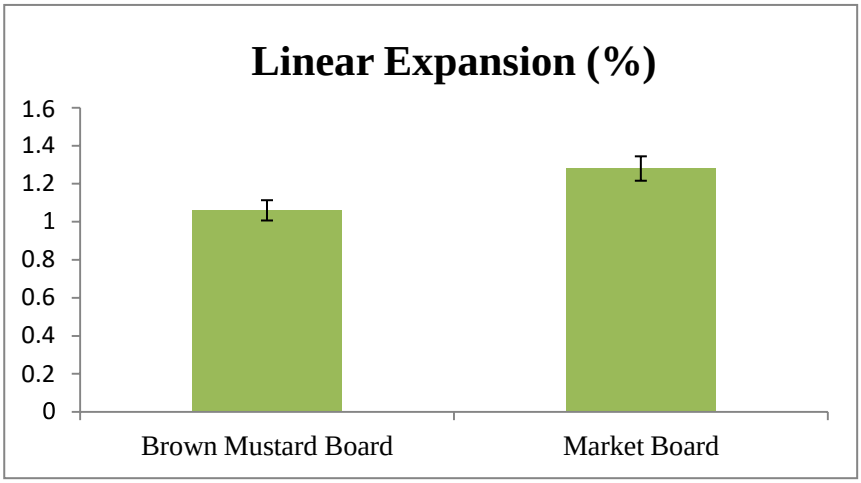

Fig 5. Linear Expansion of Brown Mustard particleboard and market particleboard after 24 hours soaking

It was found that the linear expansion of Brown mustard particleboards was 1.06% and local market particleboard was 1.28%. From the t-test, it was found that there was no significant difference (t=-

3.311, df=5 and P>0.05) of linear expansion between brown mustard particle board and market particle board. The higher slenderness ratio and the density of particles may impart the lower linear expansion than other types of boards. High density board exhibits lower linear expansion. According to ANSI A208.1–1993 (NPA, 1993), the maximum average linear expansion of standard particleboard is 0.35 %, but the specified time was not found. The linear expansion percentage after 24 hours immersion in water by standard particleboard was not found as per IS: 3087-1985, Australian and Newzealand Standard AS/NZS 1859.1: 2001.Int (The Laminex Group, 2003), British Standard BS: 5669 and German Standard DIN 68 761 (Verkor and Leduge, 1975)

3.2 Mechanical properties

3.2.1 Modulus of Elasticity (MOE)

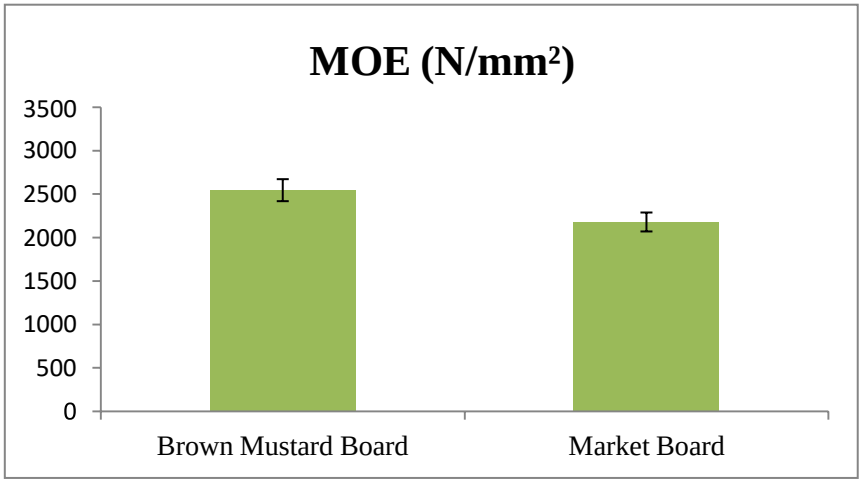

Fig 6. Modulus of elasticity of Brown Mustard particleboard and local market particleboard.

It was found that the MOE of Brown Mustard particleboards was 2546.94 N/mm² and local market particleboard was 2181.16 N/mm². From the t-test, it was found that there was significant difference (t=1.026, df=5 and P<0.05) of Modulus of Elasticity between brown mustard particle board and market particle board. According to ANSI A208.1– 1993 (NPA, 1993), the MOE of standard particleboard is 2,400- 2,750 N/mm² for high density grade, 1,725- 2,750 N/mm² for medium density grade and 550-1,025 N/mm² for low density grade. But according to Australian and Newzealand Standard (AS/NZS 1859.1: 2001.Int), the MOE of standard particleboard is 2500 N/mm² (for 18 mm thick board) (The Laminex Group, 2003).

3.2.2 Modulus of Rupture (MOR)

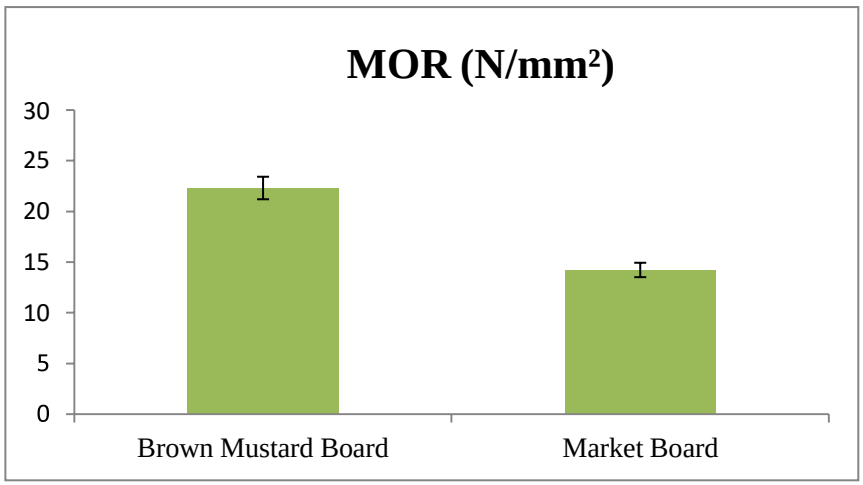

Fig 7. Modulus of rupture of Brown Mustard particleboard and local market particleboard.

It was found that the MOR of Brown Mustard particleboards was 22.28 N/mm² and local market

particleboard was 14.21 N/mm². From the t-test, it was found that there was significant difference (t=2.877, df=5 and P<0.05) of Modulus of Rupture between brown mustard particle board and market particle board.

According to ANSI A208.1–1993 (NPA, 1993), the MOR of standard particleboard is 16.5- 23.5 N/mm² for high density grade, 11.0- 16.5 N/mm² for medium density grade and 3.0- 5.0 N/mm² for low density grade. According to IS: 3087-1985, the MOR of standard particleboard is 10.98 N/mm². But according to Australian and Newzealand Standard AS/NZS 1859.1: 2001.Int (The Laminex Group, 2003), British Standard BS: 5669 and German Standard DIN 68 761 (Verkor and Leduge, 1975), the MOR of standard particleboard is 16 N/mm² (for 18 mm thick board), 13.80 N/mm² and 17.65 N/mm², respectively.

4. Conclusion

Considering the properties of particle board made from *Brassica juncea* (L.) Czern., it can be that, brown mustard plant have the potential to be used as raw material in particleboard manufacturing.

The density of Brown Mustard particleboard was 0.836 gm/cm^3, moisture content was 6.95%, water absorption was 41.86 %, thickness swelling was 18.75 % and linear expansion was 1.06%.

The MOR of the particleboard was 22.28 N/mm^2 that satisfied world standard value (21 N/mm^2) of ANSI (NPA, 1994). The MOE of the particleboard was 2546.94 N/mm^2 that satisfied world standard value (2400 N/mm^2) of ANSI (NPA, 1994).

So, the raw materials of Brown Mustard (*Brassica juncea* (L.) Czern.) can be used for manufacturing particle board or used as a filler. It can open a new research field to be used as an alternative potential raw material.

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