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UTILIZATION OF DHOL KOLMI (*Ipomea carnea*) AS A RAW MATERIAL FOR PARTICLEBOARD MANUFACTURING

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This thesis paper has been prepared for the partial fulfillment of the requirements of Four (4) years professional B. Sc. (Hons.) degree in Forestry from Forestry and Wood Technology Discipline, Khulna University, Khulna, Bangladesh.

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DECLARATION

I, Md. Mahmud Reza, declare that this thesis is the result of my own works and it has not been submitted or accepted for a degree in any other university.

I, hereby, give consent for my thesis, if accepted, to be available for photocopying and for inter-library loans, and for the title and summary to be made available to outside organizations only for research and educational purposes.

Signature

Md. Mahmud Reza

Dedicated to

My Beloved Mother and Late Father

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And at last I am extremely thankful to all my friends, well-wishers and classmates for their motivation and inspiration during this work.

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ABSTRACT

This thesis paper represents the physical and mechanical properties of Dhol kolmi(*Ipomea carnea*) particle board.. The particle board made from *ipomea carnea* presents good physical and mechanical properties. The physical and the mechanical properties of 8mm *Ipomea carnea* chips made particle board were compared with 8mm particle boards available in market. The particle board exhibits higher density, moisture content and thickness swelling than the particle board available in market. The modulus of rupture (MOR) and modulus of elasticity (MOE) of water *ipomea carnea* made particle board satisfies world standard value of ANSI, but in case of linear expansion it does not satisfy world standard value of ANSI.

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ABBREVIATION

Anon	**Anonymous**
APCC	Asian and Pacific Coconut Community
ASTM	American Society for Testing and Materials
AWPA	Australian Wood Panels Association
BBS	Bangladesh Bureau of Statistics
FAO	Food and Agricultural Organization of United Nations
g/cm^3 or gm/cm^3	Gram per cubic centimeter
Ha	Hectare
kg/m^3	Kilogram per cubic meter
kN	Kilo Newton
lb/ft^3	Pound per cubic feet
cm	Centimeter
m	Meter
mm	Millimeter
µm	Micro meter
MOE	Modulus of Elasticity
MOR	Modulus of Rupture
MPa	Mega Pascal
N/mm^2	Newton per square millimeter
PVC	Poly vinyl chloride
PP	Polypropylene
PVAC	Poly-vinyl acetate
rpm	Rotor per minute
SD	Standard deviation
UTM	Universal Testing Machine
WP	Wood particle

3.1 Materials and Equipment

3.1.1 Chipper

A locally made small lab scale chipper was used to chip the raw materials. The rpm of the chippers' motor was 1420.

3.1.2 Hot press

A digital hydraulic hot press was used to press the mat into particleboard. It has multi layer plate. The both platen were movable up and down. Maximum temperature range within 400°C and pressure up to 4MPa commonly occur.

3.1.3 Universal Testing Machine (UTM)

An analogue Universal Testing Machine (UTM), model: WE-100, made by Time group Inc. was used to determine the mechanical properties of the particleboards. There were two units of this machine, one was control unit and another was working unit. A meter was attached with the control unit for measuring the load (kN). And a scale (mm) was attached with the working unit to measure the deflection. The length of the span, on which the samples were laid, was 248 mm. Another part of the working unit was used to determine the tensile strength, which works vertically.

3.1.4 Oven

A lab scale ventilated oven (Name: Gallennkamp, Size 1, made in UK) was used to determine the moisture content (%) of raw materials as well as the particleboards. A digital indicator outside the oven indicated the inside temperature.

3.1.5 Moisture meter

An analogue moisture meter (Model: RC-1E, made by Delmhorst Instrument Co., USA) was used to measure the moisture content of particles.

3.1.6 Electric balance

An air tight digital balance (Model: AB 204, made in Switzerland) was used to measure the weight of the raw materials as well as particleboards and also used to measure the weight of different ingredients of the adhesive.

1.1 Back ground of the study:

Composites are considered to be compositions of materials in which the constitutes retain their entitles in the composition in a macro scale, that is, these do not dissolve or otherwise merge into each other completely but do in concert (Salehuddin, 1992). The wonder materials Composites, with light weight, high strength to weight ratio and stiffness properties has replaced most of the metal and alloys in recent times. Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them.

Industries today are under tremendous pressure to design ecologically friendly materials for their products. This is because of growing environmental awareness and new rules and regulations that are binding on industries. As a result researcher's choices are shifting from synthetic composite and plastics to natural composites. A substantial increase in the agricultural by products and wastes of different types has attracted many researchers to develop and characterize new and low cost materials from renewable local resources.

Wood is one of the most valuable resources on the earth and it conforms to the most varied requirements. About 70% demand for timber and 90% for fuel wood of the country is met from the trees grown in village groves of Bangladesh (Anon, 1987). There are about 150 tree species grown in homestead and village groves of Bangladesh (Das, 1990). Only a few of them are being used by ply wood, tea chest and particle board industries. 16 timber are recommended for decorative veneer and ply wood (Anon, 1986), 17 for ply wood (Anon, 1985), 46 for manufacture of ply for general purpose (Anon, 1983), 36 for plywood and batten for tea chest (Anon, 1979), and 5 selective species, viz., Civit (*Swintonia floribunda*), Garjan (*Dipterocarpus spp*), Chapalish (*Artocarpus chaplasha*), Narikeli (*Pterygota alata*), and Pitali (*Trewia nudiflora*) are recommended for particle board manufacturing plant of BFIDC (Anon, 1981). These timber species make the total of 120 which particularly from only 55 timber species out of 500 hard wood timber species available in the forest of Bangladesh (Anon, 1984). In addition Kadam (*Anthocephalus cinensis*), Chatian (*Alstonia scholaris*), Jute stick, etc are used in the private particle board industries in Bangladesh. These species are in short supply because of their extensive extraction. To reduce pressure on these species and fulfill the demand of the particleboard industries it is essential to introduce an alternative species for manufacturing particle board.

Dhol kolmi (*ipomea carnea*) is a well-known fast growing tree species. In India this is called as Behaya Ful. In our country Bangladesh, we call this Dhol kolmi. Another name is available, Dudh Kolmi, possibly for the white sap of the plant. These semi woody shrubby plants basically use to make live fence at the fields or around the house premise at villages. The leaves of this plant are toxic and for which the cattle don't show any interest on these. Flower of this Dhol Kolmi is similar to other morning glory flowers. This time this one is pink/purple in color and the crepe funnel shaped flower has a star formed inside. Botanical name of this neglected flower is *Ipomoea carnea* from the plant family *Convolvulaceae*. This plant has medical uses as it has the component of sedative. The whole plant produces white sap when torn or broken. Propagation of this plant is done by cutting in our country.

Ipomoea carnea (Besharam) which grows wild in Bangladesh has been identified as a useful material for several applications including housing. Problems associated with this material for housing are listed and a study of the structure, properties, mechanical and thermal behavior has been conducted. *Ipomoea carnea* is a lingo-cellulosic plant material with a measured tensile strength of the order of 15-25MN/m2and high flexure strength. (Zink and Allen, 1998). The habit of the plant is vine like but stems can grow up wards to a height of 5-6m on land, while the aquatic plants are shorter, growing not only near the margins in shallow water but also as rooted emergent plants 1 to 2 m above the water. The branches are found mostly at the base of the stem, which is short and stout, but firmly rooted in the soil. The powder of *Ipomoea carnea* is stable up to nearly 200oC, above which it shows signs of degradation, *Ipomoea carnea* chips, and its powder mix and bond reactively with polyester resin, cement and mud, coating of creosote, polyester, cashew-nut shell liquid and copper were successfully applied on the surface of *Ipomoea carnea.*

The following table shows the chemical composition of *Ipomoea carnea* stems as reported by Navin Chand.

Table 1.1: Chemical composition of *Ipomoea carnea* chips

Serial No.	Name of the components	Composition (%)
1	Cellulose	57.73
2	Lignin	16.59
3	Pentosan	17.30
4	Ash	6.45
5	Silica	0.16

It is imperative to study on alternate utilization of Dhol kolmi to increase its economic value. Therefore, particle board manufacturing from Dhol kolmi, as an alternative source of raw material for particle board, will add new economical dimension of the shrubs Dhol kolmi. In order to find out the suitability of Dhol kolmi as an alternative source raw material for particle board industries and to increase its economic value, chipping, flaking, drying, screening, blending and manufacturing of particle board from rain tree will be studied.

1.2 Objectives of the study:

- To introduce Dhol kolmi as an alternative source of raw material for manufacturing of particleboard and melamine board.
- To assess the feasibility of Dhol kolmi as a raw material for manufacturing particleboard and melamine board.
- To increase economic value of Dhol kolmi by utilizing it for manufacturing particleboard and melamine board.
- To carryout comparative study of quality of particleboard between Dhol kolmi and present market standard particleboard and melamine board.
- To know about physical and mechanical properties of particle board made from Dhol kolmi

2. General information about particleboard

2.1. Definition of particleboard

A particleboard is a board (or sheet) constituted from fragments of wood and/or other lingo-cellulosic materials (chips, shavings, flakes, splinters, sawdust, etc.), bonded with organic binders with the help of one or more agents like heat, pressure, humidity, catalyst, etc. (Srivastava, 1969). It may be classified as a panel product manufactured under pressure and heat from particles of wood or other lingo-cellulosic materials bonded entirely with a binder, generally a synthetic resin, to which other chemicals (e.g., fire retardant, fungicide, water retardant etc.) may be added to improve certain properties (Salehuddin, 1992).

2.2. History and Development of particle Board

Particleboards are not more than a few decades old production. First unsuccessful efforts were made in the early 1920's for manufacturing as for the lack of suitable adhesives. New techniques introduced in the 1930's in resin applications paved the way for the industrial production of particleboard in the early 1940's (Moslemi, 1985). Today's particleboard provides industrial users the high, consistent quality and range of "design" flexibility needed for fast, efficient lines and high-quality products that consumers require.

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2.3. Raw materials for particleboard manufacturing

2.3.1. Ligno-cellulosic materials

a) Planer savings
b) Sawmill residues, such as slabs, edging, trimmings, etc.
c) Residues from timber cutting in furniture and cabinet manufacturing plants.
d) Residues from match factories (Kadam, Chatian)
e) Veneer and plywood plant residues
f) Saw dusts
g) Logging residues, such as short logs, broken logs, crooked logs, small tree tops and branches, forest thinning , etc, and
h) Bark

2.3.1.1 Woody materials

- ✓ Planer savings,
- ✓ Sawmill residues, such as slabs, edging, trimmings, etc
- ✓ Residues from timber cutting in furniture and cabinet manufacturing plants,
- ✓ Residues from match factories,
- ✓ Veneer and plywood plant residues,
- ✓ Saw dusts,
- ✓ Logging residues, such as short logs, broken logs, crooked logs, small tree tops and branches, forest thinning , etc, and
- ✓ Bark (Salehuddin, 1992)

2.3.1.2 Non-woody materials

a) Jute sticks
b) Bagasse
c) Bamboo
d) Flax shaves
e) Cotton stalks
f) Cereal straw
g) Almost any agricultural residue after suitable treatment (Salehuddin, 1992).

2.3.2 Chemicals

2.3.2.1 Binder or Adhesive

Adhesives are substances capable of holding materials together in a useful manner by surface attachment. The principle attribute of adhesives is their ability to form strong bonds with surfaces of a wide range of materials and to retain bond strength under expected use conditions (Lehman, R. L., 2004).

ASTM (1997) defines an adhesive as a substance capable of holding materials together by surface attachment. The bond attained must meet the strength requirements for the structure of a whole and this bond must remain unaffected by the condition to which it will be exposed throughout its life. (Youngquist, 1999).

These adhesives have been chosen based upon their suitability for the particular product under consideration. Factors taken into account include the materials to be bonded together, moisture content at time of bonding, mechanical property and durability requirements of the resultant composite products, and of course resin system costs.

2.3.2.1.1. Types of adhesive/ binder

There are mainly two types of adhesive. One originated from natural sources known as natural adhesive and another is synthetic adhesive.

- ***Synthetic adhesive or synthetic resin adhesive***

Adhesives of synthetic origin are called synthetic adhesives. These are man made polymers which resemble natural resins in physical characteristics but which can be tailored to meet specific wood working requirements. The choice of an adhesive is based on many factors, such as cost, structural performance, moisture resistance, adhesive curing needs etc. Synthetic adhesives can be categorized into two groups, namely thermosetting adhesives and thermoplastic adhesives.

- ***Thermosetting adhesives***

These types of adhesives are usually based on formaldehyde. Thermosetting adhesives undergo a chemical change during application and curing. The bonds formed by thermosetting adhesives are generally moisture resistant and support loads under normal use. During the polymerization, or chain – building step, thermoset polymers form links, or chemical bonds, between adjacent chains. The results are a three – dimensional network that is much more rigid than the linear thermoplastic structure. The interlinked chains are not free to move when heat is applied, and the thermoset as the name implies, is "set" into a permanent shape after polymerization. The level of cross linking can be varied. Materials with high cross – linking densities are hard, rigid and somewhat brittle substances. Thermosets with low cross – linking densities can be softened by heating to high temperatures, but they do not melt and their original shape is retained (Gilleo, K. et. Al.). Some characteristics and uses of some thermosetting adhesives are furnish below –

i. Phenol formaldehyde:

Is the oldest class of synthetic polymers, having been developed at the beginning of the 20th century (Detelefsen, 2002). These resins are widely used in both laminations and composites because of their outstanding durability, which derives from their good adhesion to wood, the high strength of the polymer, and the excellent stability, exhibit high wood failure and resist delimitation.

ii. Polymeric diphenylmethane diisocyanates (PMDI)

Adhesives have shown increasing use at the expense of other adhesives due to their high reactivity and efficiency in bonding. Polymeric diphenylmethane diisocyanates (PMDI) are commonly used in wood bonding and are a mixture of the monomeric diphenylmethane diisocyanate and methylene-bridgeed polyacromatic poluisocyanates (Frazier, 2003). The higher cost of the adhesive is offset by its fast reaction rate, its efficiency of use, and its ability to adhere to difficult to bond surfaces.

iii. Urea-formaldehyde (UF)

Resins are typically used in manufacture of products where dimensional uniformity, surface smoothness are of primary concern, for example particleboard and MDF. Products manufactured with resins are designed for interior applications. They can be formulated to cure any where from room temperature (300 F); press time and temperatures can be moderated. Urea-formaldehyde resins (often referred urea resins) are more economical than PF resins and a most widely used adhesives for composite wood product (Youngquist, J. A. 1999). The inherent light color of the UF resins make them suitable for the manufacture of decorative products (Youngquist, J. A. 1999).

iv. Melamine-formaldehyde (MF)

Resin is typical of those used in the particleboard and MDF (medium density fiber board) industry. The moisture resistance of UF can be improved by adding MF (APA, 2005 and Youngquist, 1999).

v. Phenol Resorcinol formaldehyde (PRF)

PRF is also a resin- based adhesive. This adhesive is reddish – brown in color and typical of those used in the glued- laminated beam and I- joist industry and included filler. It can be recommended for the most severe environments.

- ***Thermoplastic adhesives***

Thermoplastic adhesives are especially useful because they can be used in a dry form and are already fully polymerized as received. The bonding process basically involves softening or melting the polymer while in contact with their adherents, and allowing the joint structure to cool. The structure can be easily disassembled or repositioned by reheating while applying force. These materials have been used for some time under such terms as heat-activated, hot bond and hot melt adhesives. Thermoplastic adhesives are convenient, safe and highly reliable. These are based on poly-vinyl acetate (PVAC). They generally have less resistance to heat, moisture, and long- term static loading to do thermosetting polymers. Common wood adhesives that are based on thermoplastic polymers include polyvinyl acetate emulsions, contacts, hot-melts etc. (Vick, 1999).

- ***Natural adhesive***

Before synthetic adhesives were introduced in the 1930s, adhesives made from natural polymers found in plants and animals were used for bonding wood. These adhesives were made from animal blood, hide, casein, starch, soybean, dextrin and cellulose. While natural adhesives are still being used in some non-structural products, they do not provide the necessary strength and durability required for engineered wood products.

Some natural options may someday replace or supplement synthetic resins. Tannins, which are natural phenols, can be modified and reacted with formaldehyde to produce a satisfactory resin. Resins have also been developed by acidifying spent sulfite liquor, which is generated when wood is pulped for paper. In the manufacture of wet- process fiberboard, lignin, which is inherent in lignocellulosic material, is frequently used as the resin (Suchland and Woodson, 1968). Except of two major uncertainties. UF and PF systems are expected to continue to be the dominant wood adhesives of lignocellulosic composites. The two uncertainties are the possibility of much more stringent regulation of formaldehyde- containing products and the possibility of limitations to or interruptions in the supply of petrochemicals.

2.3.2.2 Other additives

Additives are mainly used to improve the certain properties of fiber board such as moisture repellency, fire retardancy etc. Following additives are mainly used –

- ***Paraffin wax or Wax emulsion:*** This additive is generally used in small amount (1% or less) for imparting liquid-water repellency to the board.

- ***Fire retardants:*** Firer retardants are used to improve the fire resistance capacity of the board. Ammonium borate, phosphate and sulphate, diamonium phosphate and orthophosphate, zinc chloride and borate, boric acid and borax etc. are used single or in combinations, as fire retardants.

- ***Preservatives:*** Bio-deterioration is a major problem. So to avoid this, fungicides and/ or insecticides are added to the board for protection.

- ***Hardener:*** Hardener is a substance or mixture of substances added to an adhesive to promote or control the curing reaction by taking part in it. It is usually required to convert synthetic adhesives from liquid to solid (Selbo, 1975). The most common hardener used in manufacturing fiber board, composite board and particle board is Ammonium Chloride. The addition of 2% or more of Ammonium Chloride (NH_4Cl) reduces the formaldehyde release. The reduction with increasing NH_4Cl is due to combination of (-NH_4) groups with formaldehyde to produce hexamethylenetetramine (hexamine). Increasing the proportion of buffering ammonia (i.e. NH_3) also reduces formaldehyde release due to the same reason. Excessive levels of hardener will increase the danger of short storage life and increase procures. Increased buffers, beyond an optimum limit, endanger the resins fast cure rate thereby adversely influencing the strength and dimensional properties of the board. The reaction of Ammonium Chloride (NH_4Cl) with Urea formaldehyde (UF) in this particular Instance will release hydrochloric acid (HCl), hexamethylenetetramine (hexamine) and water as shown below:

$$4\ NH_4Cl + 6HCHO \longrightarrow 4HCl + 6H_2O + (CH_2O)^6N_4$$

- ***Filler or extender:*** Fillers are relatively non adhesive substances added to an adhesive binder to improve working properties, permanence, strength, or other qualities. Usually fillers are either lingo-cellulosic or inorganic in nature and are often added to reduce costs (seller's et al., 2005)

- ***Buffers:*** Buffers are added for increased storage life of adhesive and to prevent procures (Salehuddin, 1992).

2.4. Types of particleboard

2.4.1 Types of particle used

- Flake board: particleboard in which the wood is largely in the form of flakes, giving the surface a characteristic appearance. (Anon, 1970)
- Chip board: A particleboard made from chips. It is made in varying thickness and may be surfaced with paper, veneers, plastic materials, etc. (Anon, 1970)A
- Shaving board: A particleboard in which wood shavings are the chief constituents. (Anon, 1970)

2.4.2 Pressing method used

- Flat press process, where pressure is applied perpendicular to board surface, particles generally falling flat along the plane of the board surface,
- Extrusion process, where resin-bonded particles are forced between parallel hot plates or dies for consolidation and cure, particles lying largely at right angles to the board surface, and
- Molding process, where products are molded in to the desired shape with heat and pressure by using specially constructed mould or dies. (Anon, 1970)

2.4.3 *Particle size distribution in the thickness of board*

- Single layer or homogeneous board,
- Three layer board, where course particles in the core layer are sandwiched between fine particles in the face layers, and
- Multi-layer or graduated board, with a graduation of particle ranging from the finest in the face layer to the coarsest in the core (Anon, 1970).

2.4.4 *Density of the particleboard*

- Low density particleboard (below 590 kg/m^3 or 37 lb/ft^3)
- Medium density particleboard (590 – 800 kg/m^3 or 37-50 lb/ft^3)
- High density particleboard (above 800 kg/m^3 or above 50 lb/ft^3)

2.4.5 *Exposure or service condition*

- For indoor uses, where exposure to water or high humidity does not occur urea formaldehyde resin is used as the binder. Particleboards are mainly bonded with UF resin.
- For exterior use, phenol formaldehyde (PF) resin is generally used though melamine formaldehyde (MF) resin is used where the dark color of the PF resin is unwarranted.
- UF resin fortified with MF resin may be used where exposure is not very severe.
- Exterior particleboards may be classified into structural and non-structural boards.

2.4.6 *Types according to Australian standards*

- *Standard particleboard:* Particleboard suitable for general purpose and dry interior use. It is not suitable for exterior use or interior areas where wetting or prolonged high humidity conditions are likely.
- *Moisture resistant (MR) particleboard:* Particleboard suitable for areas of occasional wetting and high humidity. Not suitable where submerging, hosing or continual wetting is likely to occur.
- *High performance (HP) particleboard:* Particleboard suitable for use in certain structural applications.
- *Particleboard for flooring:* Particleboard manufactured specifically for use as domestic or industrial flooring (AWPA, 2008).

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2.5 Uses of particleboard

Particleboards are used as:

- shelves
- table tops
- cabinets
- wall cases
- benches
- book cases
- kitchen cabinets
- piano and organ parts
- flush-door cores
- mobile homes
- Floor underlayment, etc.

2.6. Advantages of particleboard

- Particleboards overcome some inherent weakness of solid wood and make useful products out of wastes, small pieces of wood and inferior species thus ensuring complete utilization of raw materials, make products with unique properties and can tailor products for particular end-use.
- The characteristic defects of wood such as knots, spiral grain, etc., may either be eliminated or scattered throughout the particleboard during manufacturing. Thus ensure not occurring defects during service condition.
- The variation in strength and stiffness due to anisotropy in wood is largely overcome as also the differential change in dimension due to absorption and desorption of moisture along or across the grain of wood.
- During the manufacture of particleboard, various treatments, such as heating, incorporation of chemical additives, etc. may be carried out to improve many physical and mechanical properties including the dimensional stability.
- By using different species and adhesives, or particles of different size and geometry, particleboard may be manufactured suitable for exposure to weather, for interior use, for interior paneling, for exterior sideboards, for load bearing flooring purposes and so on.
- Perhaps the most important advantage of particleboard is that it can be made in large dimensions (Salehuddin, 1992).

2.7. Considerations for the quality of particleboard

i. Geometry of the particles i.e. length, width, thickness, diameter, etc.

ii. Species from which the raw materials are collected.

iii. Slenderness ratio (s), i.e. the ratio of length (l) over thickness (t) of particles with square of rectangular of cross section, s = l/t, or the ratio of length over diameter (d) for round particles, s = l/d, is a highly important parameter. For the majority of properties, long thin chips, with slenderness ratio of 120 to 200 seem best. However, surface quality and internal bond strength are higher with small particles, i.e. with lower slenderness ratio (Salehuddin, 1992).

2.8 Manufacturing procedure of particleboard

2.8.1 Particle reduction from raw materials

- **Crosscutting, Splitting**

In general flake-producing machines can be fed only with logs crosscut to fix lengths (0.33, 0.38, 0.50 or 0.58 and 1 to 1.16mm. for crosscutting, automatically working band saws in conjunction with chain conveyors are produced. A unit may consist of one, two or three band saws. If the diameters of the round logs are greater than about 24cm, the wood must be slit by means of sturdy splitting machines (Kollman and Kuenzi, 1978).

- **Primary reduction, Knife Hogs:**

In many cases the primary reduction is necessary. This is useful especially for industrial wood residues, limbs and veneer wastes, ply wood edgings etc. The more common types of machines used for this reduction are knife logs. The knives may be fastened either on disks or in a number of 2 to36 knives on rotors (Kollman and Kuenzi, 1978).

- **Secondary reduction, Hammer-Mill Hogs, Toothed Disc-Mills, Impart Disc-Mills:**

Hammer-mill hogs are used as secondary reduction units. "The heart of the shredder is the hammer, hammer drum, breaker plate, and screen bars or perforated plate" (Johnson, 1956). Hourly capacity and power consumption depend on the desired degree of reduction, on wood species, on moisture content, on the size of material (for instance chips 180 to 300mm long) to be reduced, and on the desired plant capacity (Kollman and Kuenzi, 1978).

- **Sharing or Flake Production, Disc Type Chippers, Cutter Spindle and Cutter Cylinder chippers:**

Originally, only industrial residues in the form of chips were taken into consideration for the manufacture of "Artificial board" (cf. Section 5.0). Even later after the first misfortunes to produce useful and firm particleboard the utilization of industrial residues predominantly was intended (Kollman and Kuenzi, 1978).

2.8.2 Particle drying and screening

The greater part of the furnish delivered to the mill needs to be dried so that the overall moisture level of the particles is in the order of three to eight percent for the purpose of bonding with liquid resins. (Anon, 2006)

Particle drying is a continuous process with the particles moving along the length of rotating horizontal dryers whilst being suspended and exposed to hot gases or heat emitted from tube bundles which convey hot water, steam or thermic oil. Heat is produced by the combustion of oil, gas or process residues. Flash drying is now being considered an acceptable alternative to rotary dryers and requires somewhat lower drying temperatures.

Directly after drying, the particles are screened for size in vibrating or gyrating screens, or by way of air classification. Screening normally takes place after the dryers as moist particles tend to stick together, plugging screen plates and lowering the overall efficiency of the screening process.

Particles are separated according to size, for the purpose of grading the furnish for the board face and core layers. It is essential that the oversized particles be recycled for further reduction and that the fines are screened out, so as to avoid consuming a disproportionate amount of resin binder, and to provide a valued source of fuel (Anon, 2006)

2.8.3 Blending and mat forming

Adhesives in the form of urea, phenol and melamine formaldehyde are generally used to bind together the particle mix, with the former being the most favored resin in use. Between three and ten percent by weight of resin, together with other additives used to impart such properties as fire resistance, etc., are blended under controlled conditions in batches or as a continuous operation. Blending may either take place in large vats at slow speed, or in small blenders with rapid mixing and shorter blending times. In the more modern particleboard plants mat forming is a wholly mechanical process, whereas the older formers require manual equalizing. In spite of the wide variety of formers currently available, the underlying principles of mat formation are generally similar, in that a uniform flow of particles are fed to the former from a surge bin, which in turn constitute an evenly distributed layer of particles into a frame on a moving belt or caul. The formers may be fitted with single or multiple forming heads, which are either stationary or moving, and are so designed that the finest particles are delivered to form the surface layers of the mat and the coarser materials to form the core. In all cases it is paramount that an evenly distributed mat of the desired weight be formed. Mats that do not conform to standard are rejected and recycled. Transportation of the mats to the pre-press and hot press is undertaken by either forming the mat on metal plates, called cauls, which are then either manually or mechanically wheeled to the presses, or in the case of caulless systems, by using flexible metal webs, plastic belts and trays that transport the mats through to the hot-press. (Anon, 2006)

2.8.4 Pressing

Pre-pressing of the mats prior to the introduction in the multi-platen hot presses, is now becoming a common feature in the pressing operation, due to the consolidation and reduction in mat width. This allows for ease of handling and the use of narrower openings in the hot-press, thereby considerably reducing pressing time. Whereas the pre-presses may be of the hot or cold type, the main press is always heated, by passing hot water, steam or oil through the platens to attain temperatures in the order of 140-200°C, depending on the resins in use and the type of press.

Single or multiple opening hot presses may be used with the loading and unloading undertaken manually or mechanically by cable, chain lifts or hydraulics, depending on the age and sophistication of the plant. Although in the larger modern installations both pressing time and pressures are automatically regulated, hand control is still preferred in many plants as it permits adjustments to be made for the different mat qualities. (Anon, 2006)

2.8.5 Board finishing

On leaving the hot press the boards are either separated from the cauls by hand, or mechanically by means of chains or turning devices. The cauls are stacked, allowed to cool and then returned to the forming station on push carts or mechanically transported on a fixed return line. The boards in turn, are cooled and conditioned so as to avoid degradation of the urea resins. Trimming saws are used to cut the boards to size, with the edge trimmings being either recycled or used for fuel. In order to meet set standards as to thickness and surface quality, a combination of knife planers and belt or drum sanders may be used.

Once the boards have been surface finished they are cut to size along their length and widths with a combination of saws, according to the dictates of the market. Particleboard is normally produced as 1220 x 2440 mm panels with thicknesses ranging from 3-35 mm, 19 mm being the most common. Generally boards are manufactured in the medium-density range of 400-800 kg per cubic meter, although high-density board of 800-1120 kg per cubic meter is used as core stock. (Anon, 2006)

2.9 General information about Dhol kolmi (*Ipomea carnea*)

2.9.1 Classification of Dhol kolmi:

Classification:

Ipomoea carnea Jacq. ssp. *fistulosa* (Mart. ex Choisy) D. Austin gloria de la manana

Rank	Scientific Name and Common Name
Kingdom	Plantae – Plants
Subkingdom	Tracheobionta – Vascular plants
Superdivision	Spermatophyta – Seed plants
Division	Magnoliophyta – Flowering plants
Class	Magnoliopsida – Dicotyledons
Subclass	Asteridae
Order	Solanales
Family	Convolvulaceae – Morning-glory family
Genus	*Ipomoea* L. – morning-glory
Species	*Ipomoea carnea* Jacq. – gloria de la manana
Subspecies	*Ipomoea carnea* Jacq. ssp. *fistulosa* (Mart. ex Choisy) D. Austin – gloria de la manana

(http:// Plants Profile for Ipomoea carnea ssp. fistulosa (gloria de la manana).htm

- **Family:** Convolvulaceae
- **Duration:** Perennial
- **Type/growth habit:** shrubs/vine

2.9.2 Synonyms:

2.9.2.1 Non-preferred scientific names

Acmostemon Pilg.

Batatas Choisy

Bonanox Raf.

*Calonyction*Choisy

Calycantherum Klotzsch

Diatremis Raf.

Dimerodisus Gagnep.

Exogonium Choisy

Mina Cerv.

Parasitipomoea Hayata

Pharbitis Choisy

Quamoclit Mill.

Quamoclit Moench]

2.9.2.2 Common names

Dhol kolmi (*ipomea carnea*) is a well-known fast growing tree species.
Bangla: Dhol kolmi, Dudh kolmi, Hindi: Beshram, Behaya; English: Morning glory; Oriya: Behayo; Marathi: Beshram;

In our country, we call this Dhol kolmi. Another name is available, Dudh Kolmi, possibly for the white sap of the plant.

Except Ipomoea carnea, Mexican bush morning glory, I. triloba, three-lobed morning glory, and I. arborescens, morning glory treAnother common name is "bush morning glory", but particularly in temperate North America, that usually refers to *I. leptophylla*.

In Brazil, *I. carnea* is known as *canudo-de-pita*, literally "pipe-cane", as its hollow stems were used to make tubes for tobacco pipes. It thus became the namesake of Canudos, a religious community in the sertão of Bahia, over which the War of Canudos was fought 1893–1897.

2.9.3 Distribution

Ipomoea carnea is a gregariously growing short shrub available all over the world. Although it was native of South America, it was introduced in Bangladesh and India as an ornamental plant. This plant is spread all over the world including American tropics, Argentina, Brazil and Bolivia, Pakistan and Srilanka.

2.9.4 Description

Ipomoea Carnea is popularly known as Besharam, Behaya in India and Morning glory in English. It is a large diffuse shrub with milky juice. The flowers are pale rose, pink or light violet in lax, dichotomously branched axillary and terminal, pedunculate cymes; fruits have a glabrous capsule; seed is silky. The plant belongs to family Convolvulaceae. The plant part is used for Safed Dag (Leucoderma), Cyclophosphamide as aphrodisiac, purgative and cathartic. *Ipomoea Carnea* grows to a height of 6 m on terrestrial land, but acquires a shorter height in the aquatic habitats. The stem is thick and develops into a solid trunk over several years with many branches from base. The stem is erect, woody, hairy, and more or less cylindrical in shape and greenish in colour. It has alternate leaves. Normally it attains 1.25 - 2.75 m long and 0.5 - 0.8 cm diameter. The internodes measure 3.5 - 6.0 cm in length. The leaf is simple and petiolate, petiole is cylindrical, attains 4.0 - 7.5 cm length and 2.5 – 3.0 mm diameter. The upper surface of leaf is dull green and the lower surface is paler. The leaves which receive lesser sunlight may grow larger than then leaves which receive full sunlight. The difference is more in aquatic conditions Flowers of *Ipomoea Carnea* are axial. The pedicel is green, erect and cylindrical. Its length ranges between 1.5 – 2.2 cm and diameter ranges between 0.15 – 0.20 cm. The mouth of the corolla has an entire margin, with slight conspicuous depressions at the points of the cohesion of the petals, measure 5.2 - 6.0 cm long and 1.6 - 1.8 cm width at its mouth

2.9.5 Propagation and management

It is large diffuse and short shrub found around ponds, puddles and wet places in most parts of Bangladesh. This plant spreads vegetatively by stems which are capable of rooting within a few days. The plant is propagated by cuttings, and it stands pruning well. It produces dense foliage and flowers practically throughout the year, except during the cold months. It is drought resistant and can improve the soil as compost in the dry land areas. It is used as green manure crop. In India *Ipomoea carnea* can be raised both under rain fed and irrigated conditions. Therefore it can safely be used on waste lands and on river sides for controlling soil erosion. Under rain fed conditions, a border crop, 1.6 km in length, gave about 340 kN of green matter in one year in six cuttings; under irrigated conditions the yield can be double. This suggests that quantities of the order of millions of tonnes can be easily grown in areas of the order of hundred square kilometers which are readily available. The farmers use it as ornamental and hedge plant along the banks of irrigation and drainage canals. The rapid growth rate, spread, and adaptability from aquatic to xerophytic habitats indicate that this plant may potentially become an ecological disaster. The stem is thick and develops into a solid trunk over several years with many branches from base. The leaves are light green and heart shaped. The fresh stem is somewhat flexible, but the dry one breaks with a fibrous fracture exposing a whitish green interior, with hollow internodes and solid nodes. The internodes measure 3.5-6.0 cm in length.

This species is renowned as a weed all over the world and it dominates over the accompanying species. Throughout history scientist and researcher have striven hard to find ways of destroying this weed. But this weed has continued to challenge researchers by defying destruction and control. Visualizing the luxuriant growth and vigorous survival of this weed, researchers worldwide are trying to find out the potential economic value for its utilization into value added products and effective method for its management

2.9.6 Pests and diseases

Many herbivores avoid morning glories such as *Ipomoea*, as the high alkaloid content makes these plants unpalatable, if not toxic. Nonetheless, *Ipomoea* species are used as food plants by the caterpillars of certain Lepidoptera (butterflies and moths). For a selection of diseases of the sweet potato (*I. batatas*), many of which also infect other members of this genus.

2.9.7 Uses/applications

Human use of *Ipomoea* includes:

- Most species have spectacular, colorful flowers and are often grown as ornamentals, and a number of cultivars have been developed. Their deep flowers attract large Lepidoptera - especially Sphingidae such as the pink-spotted hawk moth (*Agrius cingulata*) - or even hummingbirds.
- The genus includes food crops; the tubers of sweet potatoes (*Ipomoea batatas*) and the leaves of water spinach (*I. aquatica*) are commercially important food items and have been for millennia. The sweet potato is one of the Polynesian "canoe plants", transplanted by settlers on islands throughout the Pacific. Water spinach is used all over eastern Asia and the warmer regions of the Americas as a key component of well-known dishes, such as *Canh chua rau muống* (Mekong sour soup) or callaloo; its numerous local names attest to its popularity. Other species are used on a smaller scale, e.g. the whitestar potato (*I. lacunosa*) traditionally eaten by some Native Americans, such as the Chiricahua Apaches, or the Australian bush potato (*I. costata*).
- Peonidin, an anthocyanidin potentially useful as a food additive, is present in significant quantities in the flowers of the 'Heavenly Blue' cultivars.
- Moon vine (*I. alba*) sap was used for vulcanization of the latex of *Castilla elastica* (Panama rubber tree, Nahuatl: *olicuáhuitl*) to rubber; as it happens, the rubber tree seems well-suited for the vine to twine upon, and the two species are often found together. As early as 1600 BCE, the Olmecs produced the balls used in the Mesoamerican ballgame.
- Humans use *Ipomoea* for their content of medical and psychoactive compounds, mainly alkaloids. Some species are renowned for their properties in folk medicine and herbalism; for example Vera Cruz jalap (*I. jalapa*) and Tampico jalap (*I. simulans*) are used to produce jalap, a cathartic preparation accelerating the passage of stool. *Kiribadu Ala* (giant potato, *I. mauritiana*) is one of the many ingredients of *chyawanprash*, the ancient Ayurvedic tonic called "the elixir of life" for its wide-ranging properties.

- Other species were and still are used as potent entheogens. Seeds of Mexican morning glory (*tlitliltzin, I. tricolor*) were thus used by Aztecs and Zapotecs in shamanistic and priestly divination rituals, and at least by the former also as a poison, to give the victim a "horror trip". Beach moonflower (*I. violacea*) was also used thus, and the cultivars called 'Heavenly Blue Morning Glory', touted today for their psychoactive properties, seem to represent an indeterminable assembly of hybrids of these two species.
- Ergoline derivatives (lysergamides) are probably responsible for the entheogenic activity. Ergine (LSA), isoergine, D-lysergic acid N-(α-hydroxyethyl)amide and lysergol have been isolated from *I. tricolor*, *I. violacea* and/or purple morning glory (*I. purpurea*); although these are often assumed to be the cause of the plants' effects, this is not supported by scientific studies, which show although they are psychoactive, they are not notably hallucinogenic. Alexander Shulgin in *TiHKAL* suggests ergonovine is responsible, instead. It has verified psychoactive properties, though as yet other undiscovered lysergamides possibly are present in the seeds.
- Though most often noted as "recreational" drugs, the lysergamides are also of medical importance. Ergonovine enhances the action of oxytocin, used to still *post partum* bleeding. Ergine induces drowsiness and a relaxed state and might be useful in treating anxiety disorder. Whether *Ipomoea* species are a useful source of these compounds remains to be determined. In any case, in some jurisdictions certain *Ipomoea* are regulated, e.g. by the Louisiana State Act 159 which bans cultivation of *I. violacea* except for ornamental purposes.

3.2 Manufacturing of Composite Boards

3.2.1 Collection of Raw Materials

Ipomoea carnea stem was obtained locally. The raw materials of Dhol kolmi for particleboard manufacturing was collected from Monirampur, Jessore, Bangladesh

3.2.2 Processing & Screening of Raw Materials

The outer skin layer was scraped out with the help of scissor without damaging the surface and chipped individually by using traditional hand tools. Subsequently, the chips were converted separately into particle with a grinder by using a mesh opening at 2 mm. The grinded particles of Dhol kolmi was screened through a mesh for classifying the coarse and fine particles. Particles between 2-0.5 mm were classified as coarse and the particles size less than 0.5 mm was classified as fine particles. The coarse and fine particles were used individually for making particle board. Mixture of coarse and fine particles was also used.

3.2.3 Drying of Raw Materials

After that, the raw materials were dried in an electrically heated lab scale oven at 103±3°C for 24 hours. For use with binder, the particles must be dried and moisture content reduced about 2% to 7% moisture content (Anon, 2006).

3.2.4 Mat Formation

Coarse particle

After screening and drying of the coarse particle was blended manually with Urea Formaldehyde (UF) resin and water in a drum type blender. Urea-formaldehyde resin is usually introduced in water solutions containing about 50% to 65% solids. The type and amount of resin used for particleboard depend on the type of product desired. Based on the weight of dry resin solids and ovendry weight of the particles, the resin content can range between 4% and 10%, but usually ranges between 6% and 9% for UF resins. (Youngquist, 1999)

Mixture of coarse and fine particles

Two samples were made in two different ratios of adhesive and variation in the amount of fine and coarse particle. In the first sample the proportion of adhesive in face, core and back was 10%, 15% and 10% and in the second sample it was 10%, 8%, 10%. The resin content of the outer face layers is usually slightly higher than that of the core layer. The resin content of the outer layers is usually higher (about 8% to 15%) than that of the core (about 4% to 8%). (Youngquist, 1999). For producing 8 mm particleboard, the average mat thicknesses were 32 mm. Mat is formed into 3-4 times and even 20 times thicker than the target board thickness, depending on the particle geometry and density of the raw material (Salehuddin, 1992 and Youngquist, 1999).

3.2.5 Hot Pressing

A steel sheet was placed on the mat after finishing mat formation. Then, mats were pressed on a computer controlled hot press under temperature at 140 ° C and 3 MPa pressure for 6 minutes. The temperature switch was switched off after 6 minutes. Hot-press temperatures for thermosetting materials (e.g. UF, RF, PF) usually range from 140°C to 165°C (284°F to 325°F). (Youngquist, 1999)

Pressure depends on a number of factors, but it is usually in the range of 1.37 to 3.43 MPa and >3.35 MPa for medium-density and high density boards. Upon entering the hot press, mats usually have a moisture content of 8% to 12%, but this is reduced to about 5% to 9% during pressing. This process of particleboard manufacturing is called flat-press process (AWPA, 2001 and Youngquist, 1999).

3.2.6 Conditioning

After stopping temperature the board was remained fixed for cooling or conditioning. The hot boards are removed from the press (or sawn across on continuous presses) and further conditioned to equilibrate board moisture content and to stabilize and fully cure the adhesives (AWPA, 2001).

3.2.7 Trimming

After the boards of each type were produced separately, these were trimmed at edges with the fixed type circular saw. The board is trimmed to obtain the desired length and width and to square the edges. 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).

3.3 Manufacturing place

The particle board was manufactured at Pulp and paper technology laboratory and wood lab that are controlled under by Forestry and wood technology discipline, Khulna University, Khulna. All tests for its quality (except MOE and MOR) were also done there.

3.4 Specifications of manufactured Particle Board

Table 3.1 Specifications of manufacturing WPC board from Jiga (*Lannea coromandelica*)

Dimensions (cm)	170 x 170
Thickness (mm)	8 (Average)
Layer	Single
Board Types	3
Replications	3 (for each type)
Total board manufactured	9
Binder	Urea formaldihyde

3.5 Laboratory Test

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) (Anon, 1985).

3.5.1 Preperation of samples for testing

Three replications of each type of boards were manufactured as stated earlier. For testing physical properties, three samples were collected from each board of each type. So the total number of sample was nine (9) for each type of particleboard for testing of physical properties. The Density and Moisture Content were determined on the same nine (9) samples and the Water Absorption, Thickness Swelling and Linear Expansion were determined on the other nine (9) samples. For testing mechanical properties, three samples were collected from each board of each type. So the total number of sample was nine (9) for each type of particleboard for testing of mechanical properties. The MOR and MOE were determined on the separate samples.

The dimension of samples for testing the physical properties was approximately (50 mm x 35 mm) and for testing the mechanical properties was approximately (180 mm x 35 mm).

3.5.2 Physical Properties

3.5.2.1 Surface smoothness

The surface soundness was determined by preparing a sample (50 mm x 50 mm) by gluing a metal mushroom to surface of the sample and determining the required load for breaking the bond. The IMAL machine (IB 600) was able to carry out the break cycle automatically and to determine the maximum load. The formula used in this test is the following

SS = F/A

Where,

SS = the resistance to surface soundness

F = the breaking force

A = the mushroom surface, which is standard 1000 mm^2.

(http://www.imal.it.)

3.5.2.2 Tensile strength

The IMAL machine (IB 600) was able to determine the tensile strength and it calculated by the following formula:

$$f_1 = \frac{F_{max}}{a \times b}$$

Where,

F_{max} = the breaking force

a = the length of the sample

b = the width of the sample. (http://www.imal.it.)

3.5.2.3 Axial resistance to a screw withdrawal

The samples (50 mm x 50 mm) were prepared by drilling a hole in them putting a screw into it. The spacer should be provided to help in finding the right depth and also used to hook the sample to the column. IB 600 was able to carry out the cycle autonomously and record the value of the withdrawal in the data base. It was possible to carry out the test on both face and edges. (http://www.imal.it.)

3.5.2.4 Density and density distribution

The density and moisture content of each board were calculated through measuring initial weight and oven-dry weight where oven-dry weight were obtained by drying the samples at 103±2°C until reaching a constant weight. The samples weight and dimensions of every board were measured respectively by an electric balance and a digital slide caliper. The volume of each sample was calculated as a result of multiplying the length, width and thickness.

Density (D) of each board was calculated after measuring weight and volume using the following equation-

$$D = \frac{m}{v}$$

Where m is the mass and v is the volume of each sample. ((Desch and Dinwoodie, 1996, (http://www.imal.it.))

3.5.2.5 Moisture content

After measuring the initial mass and oven-dry mass moisture content (MC) was determined by following equation-

$$mc\,(\%) = \frac{m_{int} - m_{od}}{m_{od}} \times 100$$

Where m_{int} is the initial mass and m_{od} is oven-dry mass of the sample.

((Desch and Dinwoodie, 1996, (http://www.imal.it.))

3.5.2.6 Water Absorption

The water absorption (A_w) and thickness swelling (G_t) were determined by soaked in water for 24 hours. The water absorption and thickness swelling rate were increased with the time passed. After 24 hours the water absorption and thickness swelling were calculated by an electric balance and a digital slide caliper as a percentage.

Water absorption was calculated by the following formula-

$$A_w(\%) = \frac{m_2 - m_1}{m_1} \times 100 \qquad \text{(ASTM, 1997)}$$

Where m_1 is the weight of the sample before immersion and m_2 is the weight of the sample after immersion in water.

3.5.2.7 Thickness Swelling

Thickness Swelling was determined by using the following equation-

$$G_t = \frac{t_2 - t_1}{t_1} \times 100 \qquad \text{(ASTM, 1997)}$$

Where t_1 is the sample thickness before immersion and t_2 is the sample thickness after immersion into water.

((Desch and Dinwoodie, 1996, (http://www.imal.it.))

3.5.2.8 Linear expansoin

The Linear Expansion was calculated by the following formula-

$$LX(\%) = \frac{L_A - L_B}{L_B} \times 100$$ (ASTM, 1997)

Where, L_A = Length of sample after immersion (24 hr.) in water (mm), L_B = Length of sample before immersion in water (mm).

3.5.3 Mechanical Properties

By using Universal Testing Machine followed by three point bending test modulus of elasticity (MOE) and modulus of rupture (MOR) were determined for each board. MOR and MOE were calculated by following formulas-

$$MOE = \frac{P / L^3}{4\Delta / bd^3}$$ (Desch and Dinwoodie, 1996)

$$MOR = \frac{3PL}{2bd^2}$$ (Desch and Dinwoodie, 1996)

In both equations, MOE and MOR is the modulus of elasticity (N/mm^2) and modulus of rupture (N/mm^2);

Here,

P represents load in the limit of proportionality (N);

L is the length of the span (mm);

b is the width (mm);

d is the thickness (mm) and

Δ represents the deflection at the limit of proportionality (mm).

3.6 Statistical Analysis

All the data, produced during the laboratory tests for characterization of physical and mechanical properties of each type of particleboards, were analyzed by SAS (Statistical Analysis Difference) statistical software, microsoft office excel,2010 and SPSS software.

4.1 Results

After manufacturing mechanical properties of the particle board were tested in KUET, Khulna (Bangladesh) and the physical properties were tested in the laboratory controlled by Forestry and Wood Technology Discipline in Khulna University. The result of the tested sample is given below:

Properties	Particleboard from Dhol kolmi			Market board
	Coarse particle	Coarse: Fine a (50:50)	Coarse: Fine b (40:60)	
Density (Kg/m^3)	675	690	715	637
Water absorption (%)	19.65	37.41	47.42	57.22
Moisture content (%)	10.57	12.25	13.03	8.5
Thickness swelling (%)	12.42	13.23	15.61	14.11
Linear expansion (%)	1.04	0.87	0.73	0.79
MOE (N/mm^2)	2937.52	3493.33	3868.9	2870.27
MOR (N/mm^2)	28.33	31.12	33.31	23.11

4.2 Discussions

4.2.1 Physical properties

4.2.1.1 Density of the board

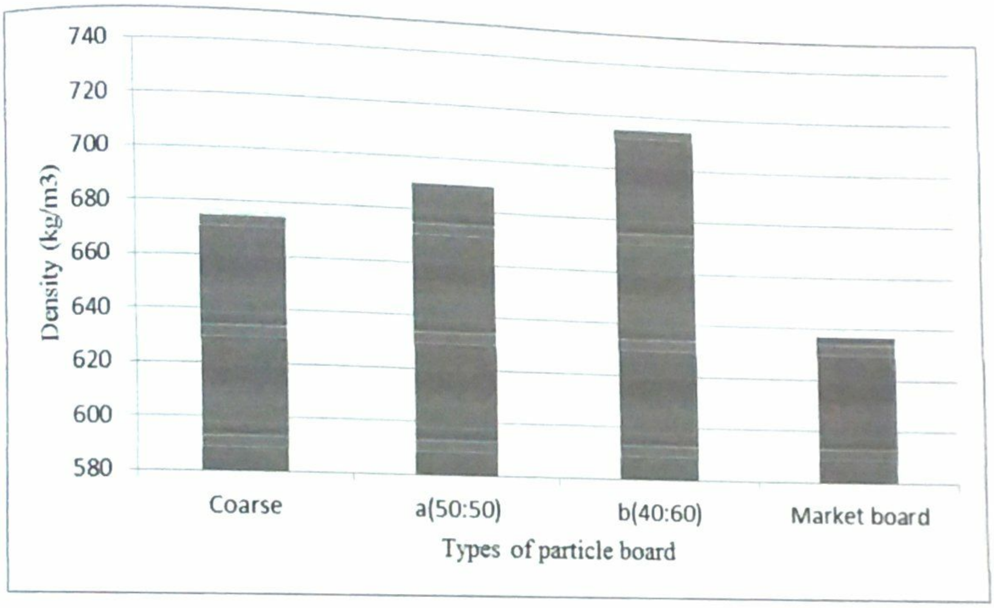

Fig.4.2.1.1 Density of Dhol kolmi particleboard and local market particleboard

It was found that the average density of Dhol kolmi particleboards from coarse particle was 675 kg/m^3, Mixture of coarse and fine were 690 kg/m^3, 715 kg/m^3 and market particleboard was 637 kg/m^3 respectively. According to IS specification 3087 (Anon, 1985) 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.

4.2.1.2 Water absorption

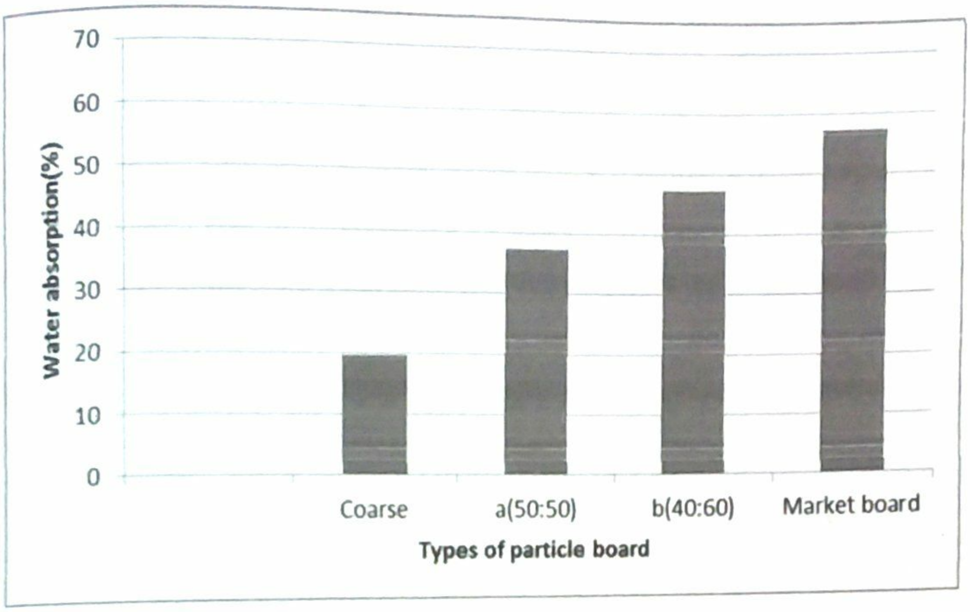

Fig.4.2.1.2 Absorption of water by Dhol kolmi particleboard and local market particleboard after 24 hours soaking

It was found that after 24 hours the percentages of water absorption were 19.65%, 37.41% and 47.42% in Dhol kolmi particleboard and 57.22% in market particleboard. According to IS specification 3087 (Anon, 1985) 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 Newzeland Standard (AS/NZS 1859.1: 2001.Int) (The Laminex Group, 2003), British Standard BS: 5669 (Anon, 1979) and German Standard DIN 68 761 (Verkor and Leduge, 1975).

4.2.1.3 Moisture content after curing

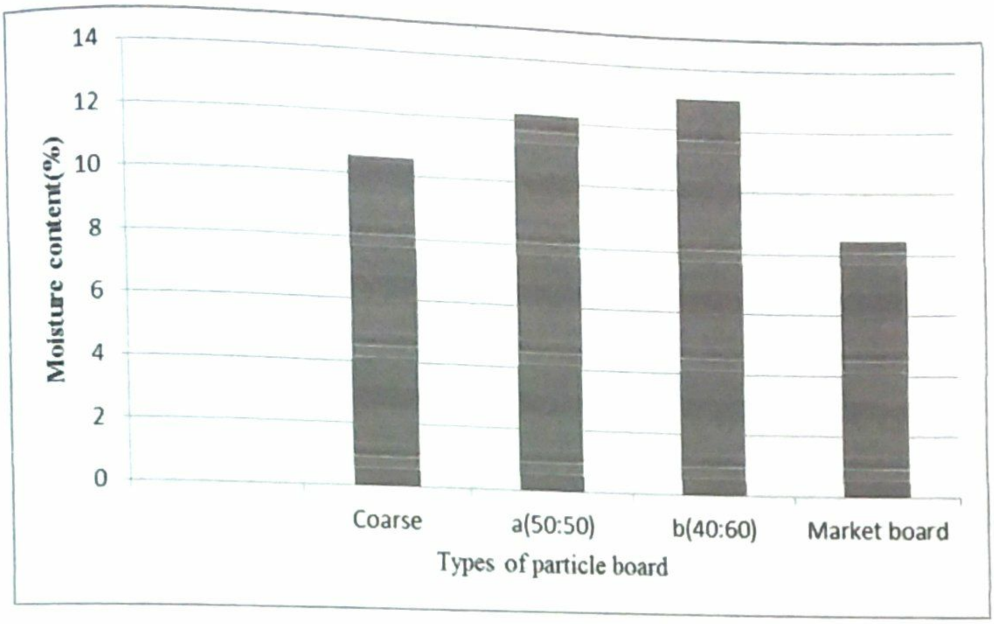

Fig.4.2.1.3 M.C. % after curing in Dhol kolmi particleboard and local market particleboard

After curing, the moisture content was 10.57%, 12.25% and 13.57% for Dhol kolmi particleboard and 8.5% for market particleboard. The maximum moisture content in the standard particleboard was not found as per ANSI A208.1–1993 (NPA, 1993) and IS: 3087-1985 (Anon, 1985) as well as British Standard BS: 5669 (Anon, 1979) and German Standard DIN 68 761 (Verkor and Leduge, 1975). But according to Australian and Newzeland 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).

4.2.1.4 Thickness swelling

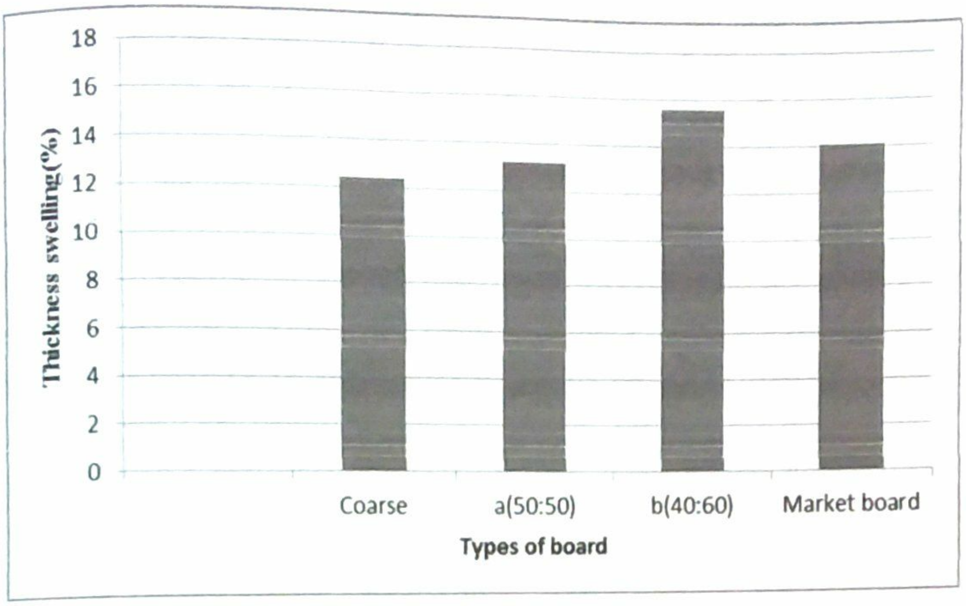

Fig. 4.2.1.4 Thickness swelling of Dhol kolmi particleboard and local market particleboard after 24 hours soaking

It was found that after 24 hours the percentage of Thickness swelling was 12.42%, 13.23% and 15.61% in Dhol kolmi particleboard and 14.11% in market particleboard.

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 (Anon, 1985) as well as British Standard BS: 5669 (Anon, 1979) and German Standard DIN 68 761 (Verkor and Leduge, 1975). But according to Australian and Newzeland 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).

4.2.1.5 Linear Expansion

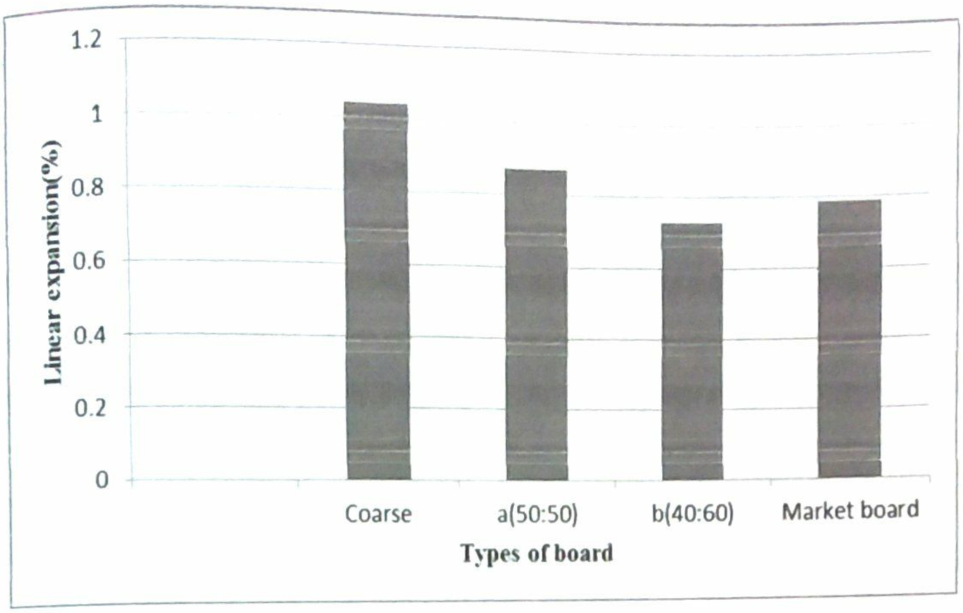

Fig. 4.2.1.5 Linear Expansion of Dhol kolmi particleboard and market particleboard after 24 hours soaking

It was found that the linear expansion of Dhol kolmi particleboards 1.04%, 0.87% and 0.73% and local market particleboard was 0.79%. 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 (Anon, 1985), Australian and Newzeland Standard AS/NZS 1859.1: 2001.Int (The Laminex Group, 2003), British Standard BS: 5669 (Anon, 1979) and German Standard DIN 68 761 (Verkor and Leduge, 1975)

4.2.2 Mechanical properties

4.2.2.1 Modulus of elasticity (MOE)

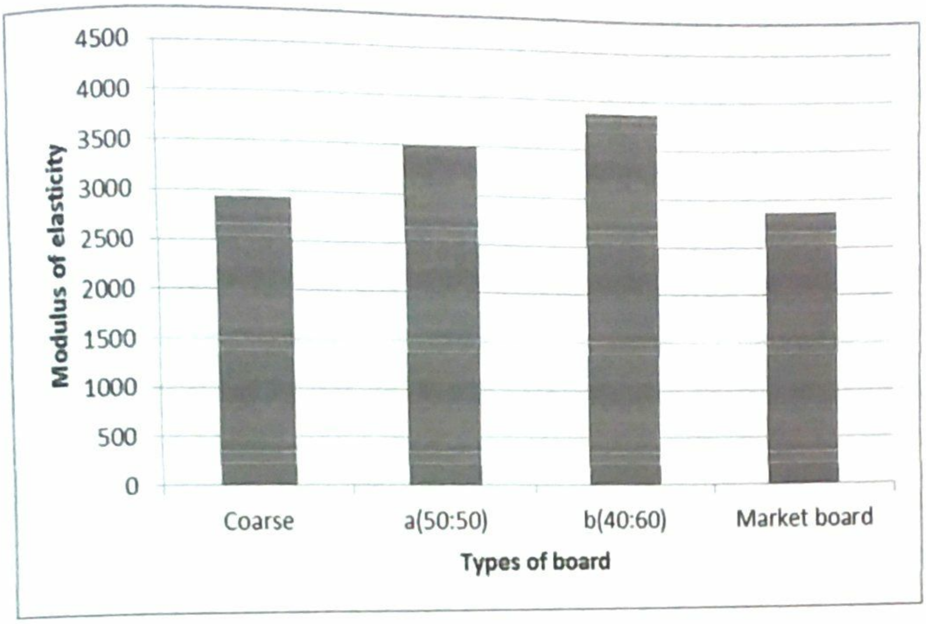

Fig. 4.2.2.1 Modulus of elasticity of Dhol kolmi particleboard and local market particleboard.

It was found that the MOE of Dhol kolmi particleboards were 2937.52 N/mm², 3493.33 N/mm², and 3868.9 N/mm² and local market particleboard was 2870 N/mm². 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 Newzeland 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).

4.2.2.2 Modulus of rupture (MOR)

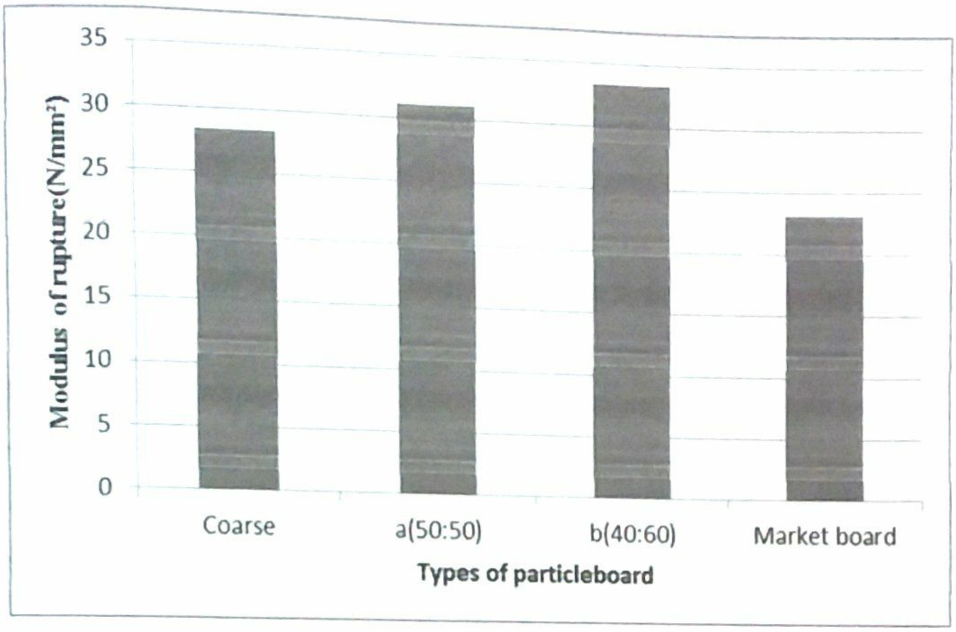

Fig. 4.2.2.2 Modulus of rupture of Dhol kolmi particleboard and local market particleboard.

It was found that the MOR of Dhol kolmi particleboards were 28.33 N/mm², 31.12 N/mm², and 33.31 N/mm² and local market particleboard was 23.11 N/mm².

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 (Anon, 1985), the MOR of standard particleboard is 10.98 N/mm². But according to Australian and Newzeland Standard AS/NZS 1859.1: 2001.Int (The Laminex Group, 2003), British Standard BS: 5669 (Anon, 1979) 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.

5.1 Conclusion

This experiment reveals that *ipomea carnea* have the potential to be used as raw material in particleboard manufacturing.

The density of 8 mm particleboard was 0.675 gm/cm^3, 0.690 gm/cm^3 and 0.715 gm/cm^3, the moisture content was 10.57%, 12.25% and 13.03%, water absorption was 19.65%, 37.14% and 47.42%, thickness swelling was 12.42%, 13.23% and 15.61% and linear expansion was 1.04%, 0.87% and 0.73%.

The MOR of the particleboards satisfied world standard value (24 N/mm$^{2)}$ of ANSI (NPA, 1994). The MOE of the particleboards satisfied world standard value (2400 N/mm$^{2)}$ of ANSI (NPA, 1994).

So, the composite materials of Dhol kolmi (*ipomea carnea*) can open a new era to be used as an alternative potential raw material in the field of particleboard manufacturing.

5.2. Recommendations

Composite board of Dhol kolmi has satisfied the physical and mechanical properties of the international standards. But further study may be carried out also with different adhesives like Phenol Formaldehyde (PF), Melamine Formaldehyde (MF), Poly vinyl chloride (PVC), Poly-vinyl acetate (PVCA) etc., with different additives like talc, wax etc. to observe variations of the board manufactured from Dhol kolmi *(ipomea carnea)*

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