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Development of Binderless Particleboard from Dhaincha Stick

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Consecrated To..........

My Treasured Parents

DECLARATION

I, Rehana Khatun, 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.

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Rehana Khatun

ABSTRACT

This study was conducted to produce binderless particleboard from dhaincha *(Sesbania aculeata)* sticks. Different temperatures (160^0C, 180^0C, 200^0C and 220^0C) were applied at same pressure (5MPa) and same pressing time (10min) to investigate the effect of temperature as well as moisture content (%) by which particleboard were produced. The target density of the board was 0.8g/cm^3. The modulus of rupture (MOR) was 11.67N/mm^2 and the modulus of elasticity (MOE) was 1633.84 N/mm^2 at 200^0C temperature and 10% moisture content. These values satisfy the standard value of ANSI. The water absorption capacity of the board manufactured at 200^0C and 10% MC was 46.73% as well as the thickness swelling was 28.54% after two hours immersion in water. It can be concluded that dhaincha can be an alternative raw material for the development of binderless particleboard.

LIST OF TABLES

TABLE OF CONTENTS

LIST OF FIGURES

ABBREVIATIONS

FAO	Food and Agricultural Organization
ASTM	American Society for Testing and Material
MOE	Modulus of Elasticity
MOR	Modulus of Rupture
TS	Thickness Swelling
WA	Water Absorption

INTRODUCTION

1.1 Background of the study

The population has increased dramatically since1960, adding 1 billion people per 15 years (Hartmann, 1998) and the world population could double to 12 billion by 2075 (FAO, 1999). As a result the natural resources mainly forests are declining at the alarming rate of 13.0 million hectares per year in developing countries (Anon, 1997). The continuing global loss of forest is a major concern to governments worldwide. There will be challenges in expanding the ability of forests to meet the needs of societies worldwide. To meet the demand of expanding pressure, alternative raw materials are major concern of the world (Anger and Brown, 1994).

The feasibility of using fast-growing trees and agricultural residues as alternative raw materials for particleboard or binderless particleboard production has been explored by a number of researchers. Particles or fiber of lingo-cellulosic material bonded together with each other and produce in panel form are gradually gaining importance in a number of countries in the world. Worldwide economic growth and development have generated unprecedented needs for converted forest products such as pulp and paper, composite boards, plywood and lumber (Youngquist et al., 1993). This global demand started with the advent of the industrial revolution resulting in aggressive deforestation (Adger and Brown, 1994).

As a small country, like Bangladesh also confronted with the same situation over the past few decades. For this reason, the forest resources of Bangladesh are decreasing day-by-day by introducing illegal extraction of timber for industrial and general purposes. On the other hand the wood based composite industries in Bangladesh faced boldly a hard situation of great lacking of available raw materials. Due to heavy industrial development, these wood based composites such as hard boards, fiberboards etc are in high demand and have to be supplied successively. So, it is now very much essential to find out alternative raw materials for these industries, not only to meet the demand but also to reduce the pressure on the presently used tree species by these industries (Adhikary et al., 2007).

Now-a-days, environmental and economic concerns are stimulating research in the development of new materials for construction, furniture, packaging and automobile industries. Particularly, many research studies have conducted on composite panels from non-wood lingo-cellulosic materials in which most are based on natural renewable resources. Non-wood lingo-cellulosic materials have been considered to produce various composite products. These resources are abundantly available in many countries; including residues from annual growth plants. Most of non-wood lingo-cellulosic materials have very low densities, which make them extremely bulky. The collection, transportation and storage of these materials call for special attention, due to the bulky nature of bagasse, cereal straw, jute, dhaincha etc and they are abundantly available (Markessini et al., 1997; Rowell, 1998; Chow, 1974).

Dhaincha is a shrub and belongs to the family Leguminoceae. In tropical and subtropical regions of the world, fifty species of sesbania have been described. Among these thirty-three species are found in Africa. The remaining 17 species are found in Australia. Ten species are found in Australlia and Hawaii 7 species (Gillet, 1963 and Burbidge, 1965). The exact number of Asian species is not known (Char, 1983). It helps in fixing of atmospheric nitrogen with its root nodules. About 18 MT of dhaincha ploughed in 1 ha that yield approximately 77 kg of nitrogen (Anon, 1950). Dhaincha fibre is coarse, silken in appearance resembling as hemp. It is resistant to sea water. It was reported that it is much superior to jute in strength and durability. (Wealth of India, 1954). It is used in industrial and domestic purposes. Such as fuelwood, green manure, fibre and pulpwood, human food and sources of gums. But in Asian reason perennial sesbania species are mostly used as a source of fuelwood for many years (NAS, 1980 and 1983).

In this study dhaincha is used as a raw material of binderless particleboard. Binderless board is a wood panel made without the use of synthetics adhesive. It is prepared by hot pressing of wood particles that involves a self-bonding process (Workshop on Technology Transfer: 15 July, 2014).It is well known that wood-based fragments can be converted into boards by steam/heat treatments without using any adhesive (Shen, 1991). This phenomenon is called self-bonding. It is improved by activating chemical components of the board's constituents during steam/heat treatment. These reactions may include (Rowell et al., 2002): degradation of both of hemicelluloses and part of the cellulose to produce simple sugars and other decomposition products (Shen, 1991;

Rowell et al., 2002; Widyorini et al., 2005); thermal softening of the cell wall matrix (Inoue et al., 1993); crosslinking between carbohydrate polymers and lignin (Suzuki et al., 1998) and an increase in cellulose crystallinity (Tanahashi et al., 1989, 2000).

1.2: Objectives of the study

The objectives of this research were-

- To study the potentiality of dhaincha as a raw material for binderless particleboard production.
- To evaluate the physical and mechanical properties of dhaincha binderless particleboard.

CHAPTER 2
LITERATURE REVIEW

2.1 Scientific classification of Dhaincha (*Sesbania aculeeata)*

Sesbania aculeata (Willd) Pers.

Kingdom: Plantae

Unranked: Angiosperms

Unranked: Eudicots

Unranked: Rosids

Order: Fabales

Family: Fabaceae

Subfamily: Faboideae

Genus: Sesbania

Species: Sesbania aculeata

Botanical name: *Sesbania aculeata (Willd)* Pers.

Figure 2.1 Dhaincha Plantation

2.2: General description

The name Sesbania is taken from its Arabic name Siesaban. It is known by many common names, including danchi, dunchi, dhaincha, canicha, prickly sesban, ""Jantar"" or spiny sesbania. It is native to Asia and North Africa. It is most common in tropical Africa where it grows as a common noxious weed. It has been introduced to the Americas also. It may grow on saline soil. *S. aculeata* is adapted to wet, heavy soil but apparently adapts easily to drought-prone or sandy regions. It is cultivated widely in India and it is grown in rice paddies in Vietnam for use as firewood. It is an annual shrub which can grow to seven meters in height but usually only reaches one to two meters. It sends out fibrous, pithy stems with long leaves and bears purple-spotted yellow flowers. It produces pods which contain light brown beans.

Dhaincha (*Sesbania aculeata*) is a leguminous species with various environmental advantages. It is cultivated in user or waste land for its reclamation or green manuring of the soil with source of organic matter and nitrogen fixer. This land can be utilized for production of eco-friendly, biodegradable and natural fiber. Dhaincha products being bio-degradable decompose in the soil at the end of product life-cycle (Singh and Rani, 2013). Towards global warming, a concern of much importance in the present world, while the synthetic materials are being considered as the root of many problems, the natural fiber products are proven to be absolutely harmless (International jute study group, 2011).

The main reason for the opportunities of dhaincha is the worldwide awareness on environment. Sesbania species are known to fix between 500 to 600 kg/ha of nitrogen per year. In a green manure experiment in Maseno, Kenya (Onim, 1986) reported that *S. aculeata* fixed up to 250 kg N/ha in six months. Since urea fertilizer contains 46%N, this fixation is equivalent to approximately eleven 50-kg bags of urea fertilizer in six months. The use of dhaincha as a green manure (GM) crop is a common practice in Southeast Asia. Several studies have shown that dhaincha can return into the soil as GM between 80 and 120 kg of N within 90 days (Dargan *et al.*, 1975; Bhardwaj *et al.*, 1981). It is bio-degradable and its products can be easily disposed without causing environmental hazards. The roots of dhaincha plants play a vital role in increasing the fertility of the soil. Dhaincha plant have carbon dioxide assimilation rate and it clean the air by consuming large quantities of carbon dioxide (Singh and Rani, 2013). So, the research aims are to evaluate and review the impacts of dhaincha in Bangladesh in the context of Bangladesh. After all, reviewing the literature it has been found that there is no reaserch on dhaincha binderless particle board done yet. So, it has been tried to develop a dhaincha binderless board.

2.3: Major types of dhaincha in our country

2.3.1: *Sesbania aculeata*

The legume *Sesbania bispinosa*, also known as *Sesbania aculeata* Pers. It is a small tree in the genus Sesbania. It is one of the sources of promise fiber and considered to be of finer quality than fiber from *S. grandiflora*. The plant has a great number of uses, including as green manure, fodder. It can be used like industrial hemp for rope, nets sailcloth. The foliage makes a good fodder for livestock and the beans can be fed to fowl.

2.3.2: *Sesbania grandiflora*

Sesbania grandiflora also known as vegetable hummingbird, agati or hummingbird tree. It is a small tree in the genus Sesbania. It is a fast-growing tree. It leaves are regular and rounded and red in color according to its species. The fruits look like flat, thin green beans. The tree is extremely frost sensitive. It is indigenous from Malaysia to North Australia and cultivated in many parts of India and Sri Lanka. It has a lot of traditional uses. It grows hot weather and humid temperature. It will die in snowy or cold weather, fully tropical plant. It contains amino acids such as arginine, cysteine, histidine, isolcucine, phenylalanine, tryptophan, valine, threonine, alanine, aspargine and aspartic acid. It is also a good source of fatty acids such as linolenic acid. It contains major proportions of sugars such as rhamnose.

In this study *Sesbania aculeata* is used as a raw material for manufacturing of binderless particleboard. I tried to make binderless board using dhaincha in eco-friendly way. It is possible to make binderless board using dhaincha because it contains higher amount of hemicelluloses (23.4%) and lignin (23%) that is the main component of binderless particleboard.

2.4: Properties of Dhaincha

Table 2.1.1: Chemical composition of Dhaincha (Jahan and Rahman, 2013)

Constitutes	Dhaincha
Alpha-Cellulose	41.1%
Hemicelluloses	23.4%
Lignin	23%

Binderless board prepared by hot pressing of wood particles that involves a self-bonding process. The mechanism of self- bonding during steam/heat treatment has not been completely elucidated. However, the degradation of hemicelluloses during steam/heat treatment is believed to play an important role in self-bonding. Therefore, binderless boards are usually prepared from non-wood raw materials, which are rich in hemicelluloses (Jianying, 2005). Dhaincha is rich in hemicelluloses and very light in weight, it seems to be a good raw material for making binderless particleboard.

Table 2.1.2: Physical properties of dhaincha (Sigh and Rani, 2013)

Ultimate cell length(L)	2.4mm
Ultimate cell breadth	21 Micrometre
Density	120-135 kg/cm^3
Moisture regain (%)	7.13
Fibre bundle strength (g/tex	19.13
Fibre elongation (%)	2.13
Fibre fineness (denier)	39.47

2.5: Major uses of Dhaincha:

The plant has a great number of uses, including as green manure, rice straw, wood and fodder.

- It may be used like industrial hemp for rope, fish nets, sackcloth and sailcloth.
- Its fibers are similar to those of birch trees and can be used as a source of paper fiber.
- The beans can be fed to fowl and the foliage makes a good fodder for livestock.
- People use the plant as a famine food.
- Natural gum that is collected from the plant that is useful as a thickening agent.
- Like other legumes, it may be cultivated to improve the soil via nitrogen fixation.
- It makes good firewood.
- The beans used in poultices to treat ringworm and other skin infections.
- In Southeast Asia, it is used as vegetable.

CHAPTER 3

MATERIALS AND METHODS

3.1 Collection and preparation of raw materials

Dhaincha (*Sesbania aculeata*) species were collected from gopalgonj district of Khulna division. Dhaincha (*Sesbania aculeata*) species about 1.2m long and 10-12mm in diameter was used as raw material. First, the dhaincha stick was cut into chips about 3-4 cm in length. Then the chips were entered into grinding machine with the mesh size of 0.25-0.50 mm.

Figure 3.1: Raw material

3.2 Binderless board manufacture

3.2.1 Mat Formation: The weight of the dhaincha stick particle was measured according to their target densities, after which the particles were turned into mat by using a forming box. The mats were pressed repeatedly during formation. Particles are evenly spread in the frame to allow equality in shape.

Fig 3.2.1: Process of mat formation

3.2.2 Hot pressing

In hot press machine, time and pressure had to set. Temperature was allowed to raise up to the desired limit and the desired limit was 200°C. The mat was covered with steel sheet and then inserted into the hot press for pressing. The pressure (5 MPa) was remained for 10 minutes. After 10 minutes the machine was switched off. So, the temperature was dwindled gradually but retained the pressure for 10 minutes. The mat was allowed to cool for 30 minutes after switched off. Then the pressure removed and brought out the board. The board was then allowed to cool.

3.2.3. Trimming

After the board was manufactured, the edges of the board were trimmed with the fixed type circular saw. The well pressed boards were then cut into reasonable sizes to test the boards in the laboratory.

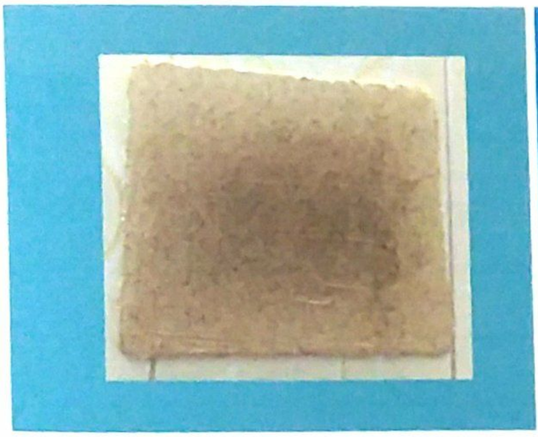


Fig.3.2.2: Board before trimming

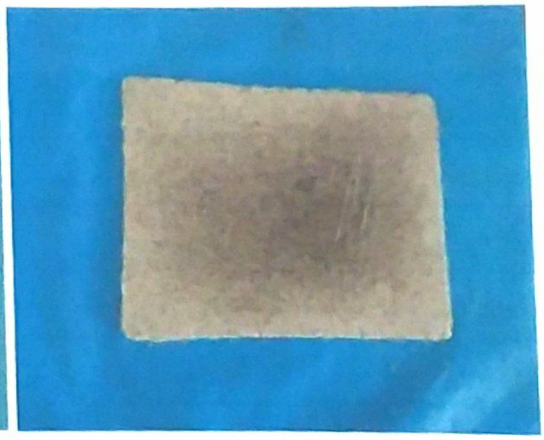
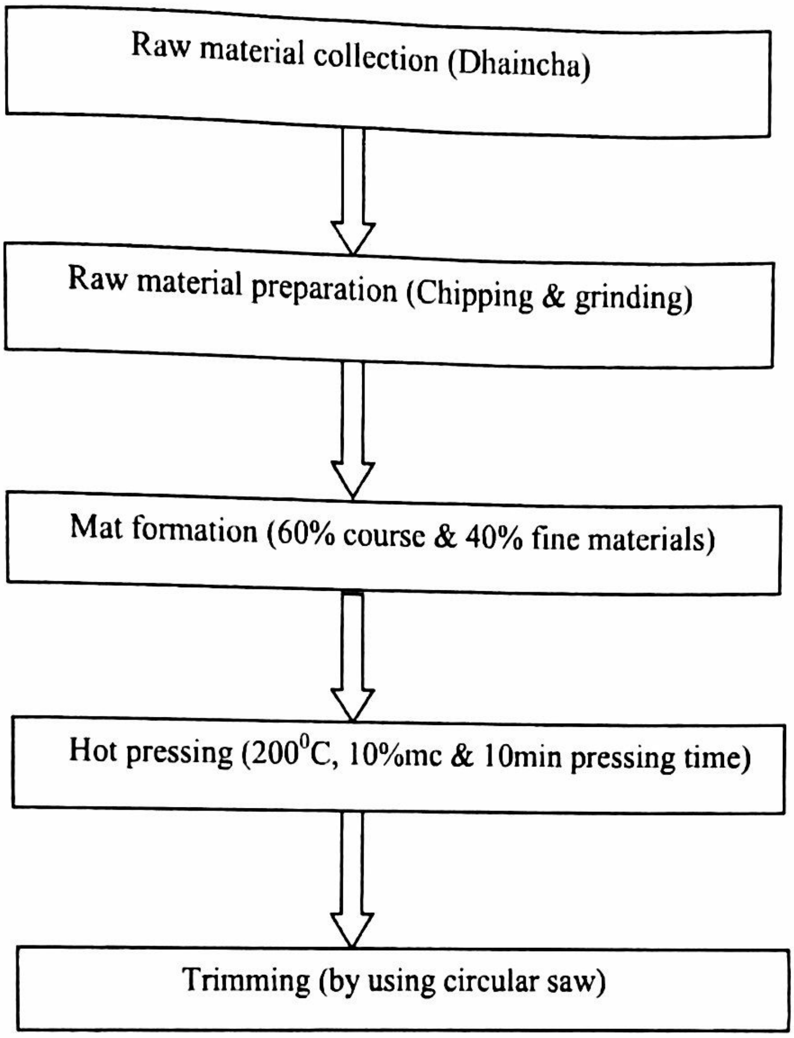


Fig.3.2.3: Board after trimming

3.2.4 Flow Diagram of Dhaincha Binderless Particle Board Production



3.3 Laboratory test

The physical properties of the binderless boards were assessed in the Wood Technology Laboratory, Pulp and Paper Laboratory of Forestry and Wood Technology Discipline in Khulna University of Engineering and Technology (KUET), Khulna, Bangladesh.

3.3.1 Density

Density of each sample was measured in the Wood Technology Laboratory of Forestry and Wood Technology Discipline of Khulna University, Khulna. Density was calculated by the following formula-

$\rho = \frac{m}{v}$ (Desch and Dinwoodie, 1996)

Where, m= Mass of the sample in gm and v= Volume in cm^3

3.3.2 Moisture content

The moisture content was determined, from the differences in weights before and after the sample has been drying in the oven. Initial and final weight of the samples was measured by electric balance. It was calculated by the following formula-

$$MC\ (\%) = \frac{Green\ weight - oven\ dry\ weight}{Oven\ dry\ weight} \times 100$$

Where,

MC = moisture content (%)

3.3.3 Water absorption

Water absorption is expressed in percentage and defined as the difference in weight before and after immersion in water. The water absorption was calculated by the following formula-

$$Aw = \frac{M2 - M1}{M1} \times 100$$

Where,

Aw= Water absorption (%)

M_2- the weight of the sample after (24hr) immersion in water (gm)

M_1= the weight of the sample before (24hr) immersion in water (gm)

3.3.4 Thickness swelling

Thickness swelling was expressed in percentage and calculated by the following formula-

$$G\,t = \frac{T2 - T1}{T1} \times 100$$

Where,

G_t = thickness swelling (%)

T_2- Thickness of sample after immersion (24hr) in water (mm)

T_1- Thickness of sample before immersion (24hr) in water (mm)

3.3.5 Static Bending Strength Test

3.3.5.1 Modulus of rupture (MOR)

Modulus of rupture (MOR) was expressed in N/mm^2 and measured with the Universal Testing Machine (UTM), model: WE-100, made by Time Group Inc. in the Laboratory of Engineering Department of Khulna University of Engineering and Technology (KUET), Khulna. The MOR was calculated from the following equation-

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

Where,

p= Load in N

l= Span length in mm

b= Width of test sample in mm

d= Thickness of test sample in mm

3.3.5.2 Modulus of elasticity (MOE)

The modulus of elasticity (MOE) was expressed in N/mm^2 and measured with the Universal Testing Machine (UTM), model: WE-100, made by Time Group Inc. in the Laboratory of Engineering Department of Khulna University of Engineering and Technology (KUET), Khulna. The MOR was calculated from the following equation-

MOE = $\frac{pl^3}{4\Delta bd^3}$ (Desch and Dinwoodie, 1996).

Where,

MOE is the modulus of elasticity in N/mm^2

p= Load in N at the limit of proportionality

l= Span length in mm

Δ = The deflection in mm at the limit of proportionality

b=Width of sample in mm

d=Thickness/ depth of sample in mm

3.4 Analysis of Data

All the data, obtained during the laboratory tests for characterization of mechanical properties of each type of particleboards, were analyzed by using Microsoft Office Excel 2007 software.

CHAPTER 4

RESULT AND DISCUSSION

Several attempts were taken to make board at different temperatures and moisture content. It was possible to make board when they were treated with 160^0C at 10% MC, 180^0C at 10%MC and 200^0C at 10% MC with pressing time 10 min. After observing the mechanical properties and dimensional stability, it has been shown that 160^0C and 180^0C treated board shown lower mechanical properties and dimensional stability as well as these values are not satisfy the standard value of ANSI. Fig. 4.1 shows the effect of temperatures on board quality. This may be the result of chemical behavior of hemicelluloses or hemicelluloses of dhaincha do not act perfectly as binder at this temperature. This may be one of the reasons of lower mechanical properties and dimensional stability of boards that were made at 160^0C and 180^0C temperature and 220^0C it was burned because of excess heating. After that 200^0C board were treated with 15% and 20%MC. After observing the moisture content effect it has been shown that 10% MC treated board shown better performance among the boards. In this study it was found that 200^0C at 10% moisture content and 10 min pressing time it was possible to make binderless board with the dhaincha and that board showed good performance as well as these values satisfy the standard value of ANSI(ANSI A208.1-1993; NPA, 1993).

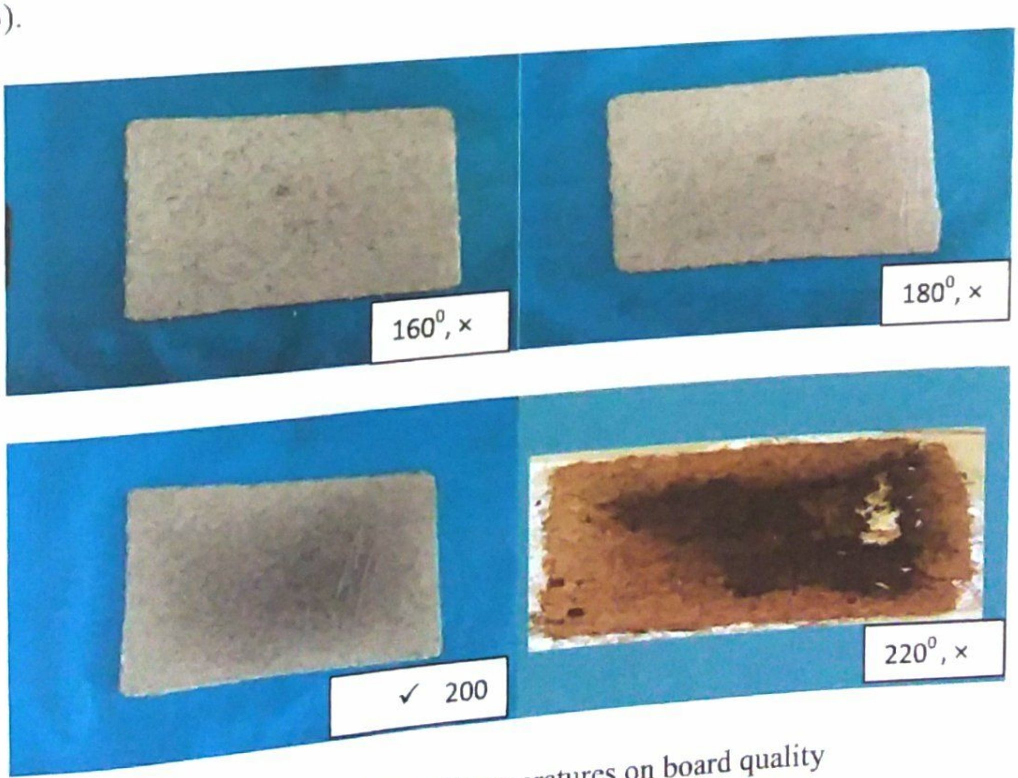


Fig. 4.1 Effect of temperatures on board quality

4.1 Density and moisture content:

Density is an important parameter and it virtually affects all the parameter of binderless board. The target density of the board was 0.8g/cm^3. The board density ranges were 0.79-0.8g/cm^3. That satisfies the target density. Pressing temperatures or press pressures may have important effect on board density. Medium density particle board density was 0.75g/cm3 (ANSI A208.1-1993). Density depends on the density of raw materials used, hot pressing conditions and other factors (Hsu et al., 1988; Sekino, 1999; Volasqueze et al., 2003). The steam-exploded fibers of oil palm frond binderless board had density lower than 0.70 g/cm3. The density of binderless board made with palm date tree without stem injection was 0.97 g/cm3 (Saadaoui *et. al.*, 2013). The variation in density between dhaincha binderless board and medium density particle board may be due to the variation of the raw materials itself. Arias (2008) emphasized four factors that are significantly important for the density and these factors are pretreatment temperature, pretreatment time, pressing temperature and initial pressing pressure. Density also may depend on the proper distribution of lignin between the particles during pressing process. To allow a good distribution of lignin between the particles during the pressing process, it is necessary to apply enough heat and pressure to melt the lignin through the whole board (Arias, 2008).

The moisture content ranges of the board were 4.29-5.97%. The moisture absorption in particleboard is mainly due to the gaps and flaws at the interfaces and the micro-cracks in the matrix formed during the manufacturing process. The moisture content ensures good mechanical properties and dimensional stability. The moisture content of the medium density particleboard was 9% (ANSI A208.1-1993). The moisture content is decreasing with increasing temperature. Temperature has direct impact on moisture content as temperature is related to the melting of lignin. If any board is produced by higher temperature, it absorbs less moisture content. At the elevated temperatures, the moisture is removed from the board and melted lignin distributed equally in the board and sealed the lumen of the particles (Mancera et al., 2011).

4.2 Effect of Hot-pressing Temperature on Board Properties

4.2.1 Mechanical Properties

4.2.1.1 MOR (Modulus of Rupture)

Fig 4.2.1.1 shows the effects of temperature on modulus of rupture of dhaincha binderless particleboard. The modulus of rupture of dhaincha binderless board was increasing with increasing temperature.

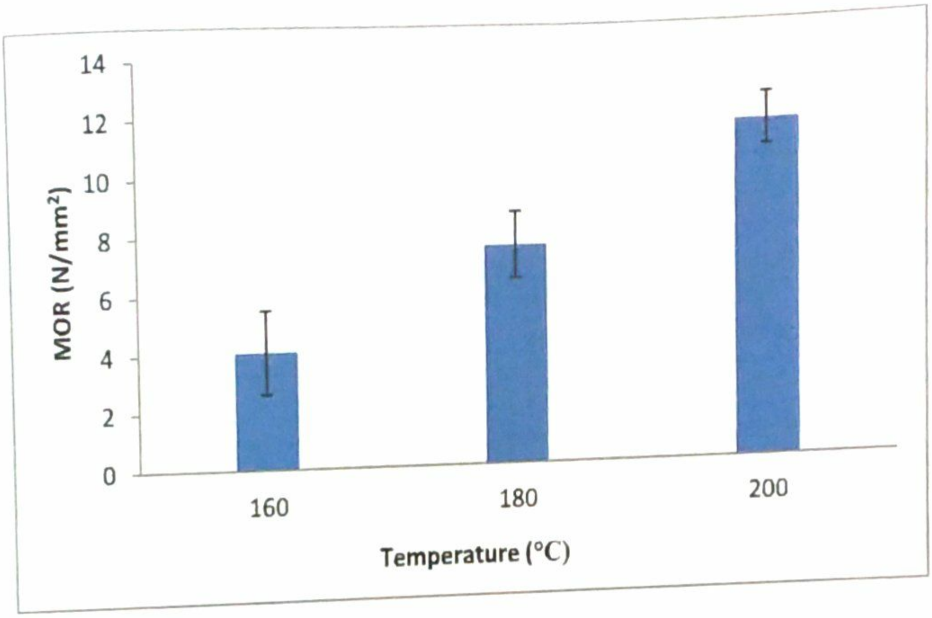


Fig. 4.2.1.1 Effect of temperatures on Modulus of Rupture (MOR) of

Dhaincha Binderless Particleboard at 10% moisture content

The MOR of medium density particle board was 11 N/mm^2 (ANSI A208.1-1993; NPA, 1993) and MOR of palm date binderless board was 12.9 N/mm^2 (Saadaoui et.al. 2013). The MOR (11.67 N/mm^2) of dhaincha binderless board (200^{0}C, 10% MC) was close to the MOR of medium density particle board. This variation is may be due to the variation of hot-pressing temperature. The modulus of rupture of board is believed to relate with hot-pressing temperature. To acquire high MOR, high temperature is needed. Compared to the density and steam pressure, the steam treatment time has less effect on MOR (Widyorini *et al.*, 2005). Arias (2009) showed that low pressing temperatures and long pressing times enhance MOR, which agrees with density behavior. Mechanical properties of boards depend on many factors. It is related to cellulose and lignin content of the material (Arias, 2008; Suschland, 1987). It may be dependent on the behavior of chemical components of dhaincha particle.

4.2.1.2 MOE (Modulus of Elasticity)

The modulus of elasticity (MOE) of dhaincha binderless particleboard was increasing with increasing temperature (Fig. 4.2.1.2).

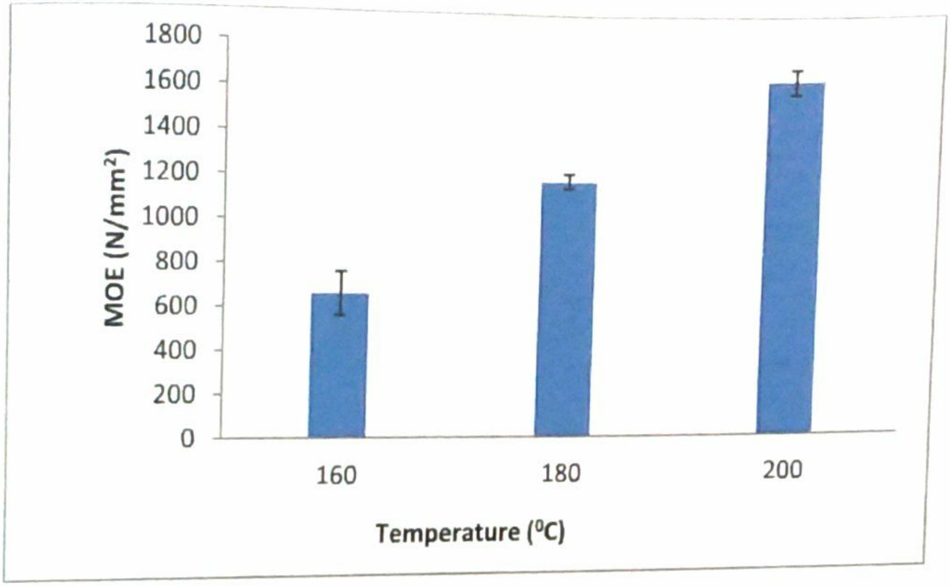


Fig. 4.2.1.2 Effects of temperature on Modulus of Elasticity (MOE) of Dhaincha Binderless Particleboard at 10% moisture content

The MOE of medium density particleboard was 1725 N/mm^2 (ANSI A208.1-1993). The MOE (1633.84 N/mm^2) of dhaincha binderless board (200^0, 10% MC) was close to the MOE of medium density particle board. It may depend on the nature and the extent of natural bonding among the chemical components of dhaincha particles. Widyorini *et al.*, (2005) found that partial degradation of three major chemical components of the kenaf core by mild steam injection treatment increased the bonding performance and dimensional stability of the binderless boards. Modulus of elasticity of binderless particle board is also related with the chemical components of the particles and density of the board. It has found that mechanical properties of the boards are related to cellulose and lignin content of the materials (Arias, 2008; Suchsland, 1987). The MOE also depends on board density. Some study showed that if density is higher the MOE also gets increased.

4.2.2 Dimensional Stability

4.2.2.1 Water Absorption

Water absorption capacity is an important factor in the case of binderless particleboard. In the case of dhaincha binderless board after half an hour soaking in water the board treated at 160^0C temperature was delaminated. In this study we found that the water absorption capacity of the dhaincha binderless particle board was higher at 180^0C than 200^0C temperature (Fig. 4.2.2.1).

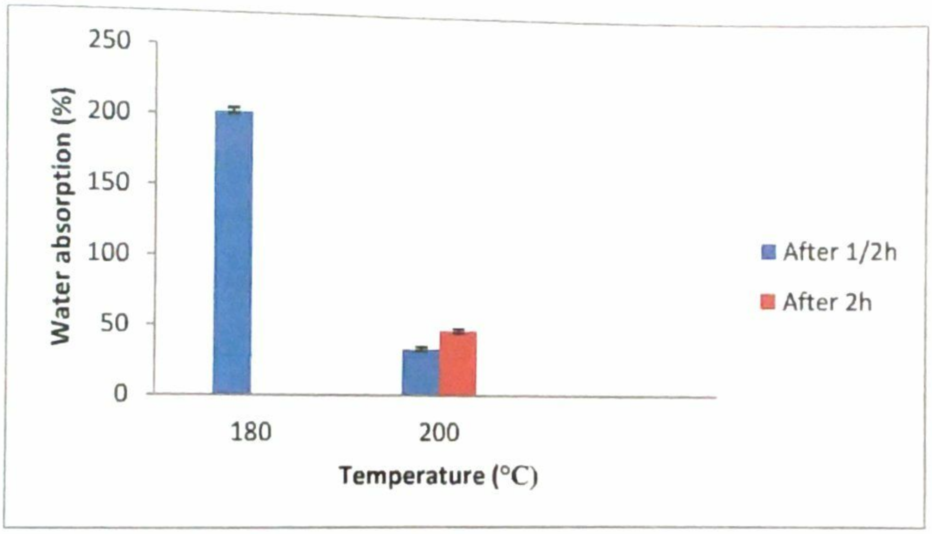


Fig. 4.2.2.1 Effect of temperatures on water absorption of dhaincha binderless particleboard at 10% moisture content

We also observed the water absorption capacity of the board after 24 hours. After 24 hours the board at 200^0C was delaminated. Due to presence of hydroxyl and other polar groups in variation constituents of dhaincha particle, the moisture uptake is high. All this leads to weak interfacial bonding between dhaincha particle and the relatively more hydrophobic matrices. But when it was treated with high temperature, the moisture uptake is lower. It may due to the high compaction of the particles. Board density has a significant effect on the water absorption. The physical and mechanical properties of binderless board also influenced by water absorption capacity of samples (Kumar, 2008). Binderless board made with spruce and pine showed water absorption 45% and 75% (Angles *et al.*, 1999). Water absorption decreased with increasing board density in the case of kenaf core binderless board. Low density board had high water absorption compared to medium density particleboard (Widyorini et al., 2005). The higher amount of hemicelluloses content in dhaincha may lead to the higher affinity to moisture. In the case of fiberboards, the dimensional stability of the fiberboards is related to partial hemicelluloses hydrolysis because hemiocelluloses are very hydrophilic (Arias, 2008). Dhaincha contains about 23.4% of hemicelluloses (Jahan and Rahman, 2013). Sekino et al., (1999) indicated that the production in hygroscopicity, which is due to the changes in hemicelluloses during steam treatment, is one factor for improving the dimensional stability.

4.2.2.2 Thickness Swelling

Thickness swelling is related to the dimensional stability of the boards. The thickness swelling of dhaincha binderless particle board after half an hour soaking in water the board treated at 160^0C temperature was delaminated.In this study we found that the thickness swelling percentage of the dhaincha binderless particle board was higher at 180^0C than 200^0C temperature (Fig. 4.2.2.1). After two hours the board at 180^0C was delaminated and the thickness swelling percentage of the board was comparatively higher than the board manufactured at 200^0C (Figure 4.2.2.2). We also observed the thickness swelling percentage of the board after 24 hours. After 24 hours the board at 200^0C was delaminated. The property gives us an idea of how the boards will behave when used under conditions of severe humidity and are especially important regarding boards that are to be used externally (Manacera *et al.*, 2011).

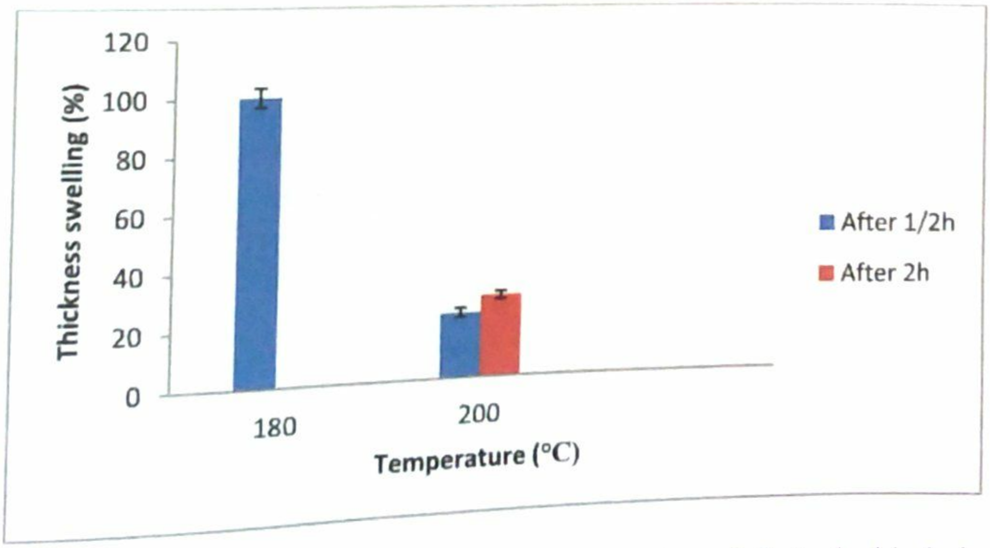


Fig. 4.2.2.2 Effect of temperatures on thickness swelling of dhaincha binderless particleboard at 10% moisture content

Thickness swelling varies between 5.8% and 14.7 % in the case of particleboard (JIS A5908). In the case of medium density particle board thickness swelling of the board was 8 % (ANSIA 208.1-1993). Binderless boards made from spruce and pine showed thickness swelling 12 % and 37% (Angles *et al.*, 1999). So, thickness swelling of dhaincha binderless board was comparatively higher than other boards. The factors affecting water absorption are responsible for the thickness swelling of dhaincha binderless particle board. The thickness swelling value is believed to relate with density. In the case of kenaf core binderless board the thickness swelling values showed a trend to increase with increasing density. This may be due to the high spring back (Widyorini *et al.*, 2005).

4.3 Effect of moisture content on board properties:

4.3.1 Mechanical Properties:

4.3.1.1 MOR (Modulus of Rupture)

Modulus of rupture significantly related with moisture content that decreasing with increasing moisture content. Fig.5.1.1 shows the effects of moisture content on modulus of rupture of dhaincha binderless particleboard at 200^0C temperature.

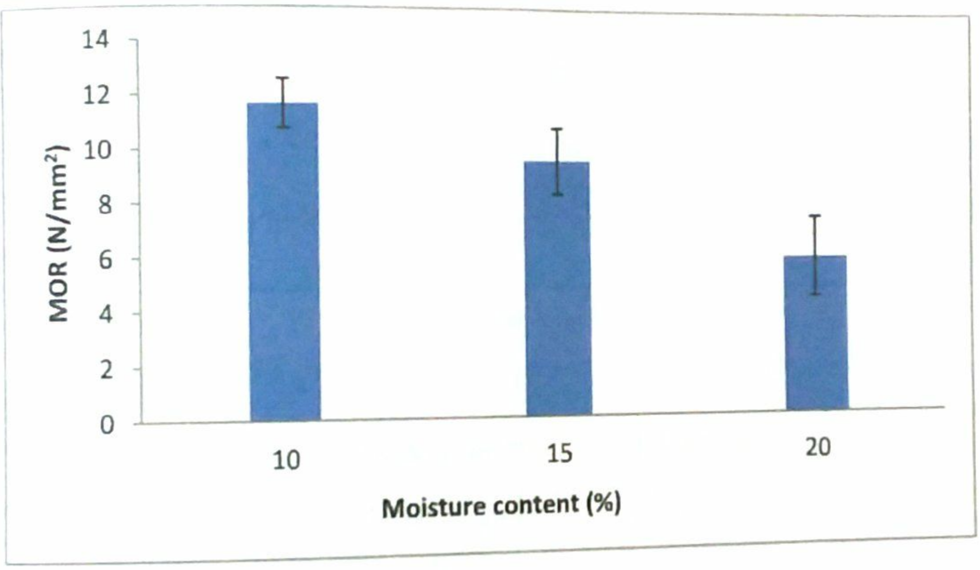


Fig.4.3.1.1 Effects of moisture content on modulus of rupture of dhaincha binderless particleboard at 200^0C temperature

The MOR of medium density particle board was 11 N/mm^2 (ANSI A208.1-1993; NPA, 1993). From the fig.5.1.1 it has been shown that the modulus of rupture of the board at 200^0C and 10% moisture content was higher than 15% and 20% moisture content treated board. Because here internal self-bonding was low, it may be the low contribution of cellulose as well as lignin. The MOR of the binderless boards is also affected by the moisture content present in the particles (Widyorini *et al.*, 2011). The nature and the extent of natural bonding are the important parameters affect the mechanical properties.

4.3.1.2 MOE (Modulus of Elasticity)

Modulus of elasticity also significantly related with moisture content that decreasing with increasing moisture content. Fig.5.1.2 shows the effects of moisture content on modulus of elasticity of dhaincha binderless particleboard at 200^0C temperature.

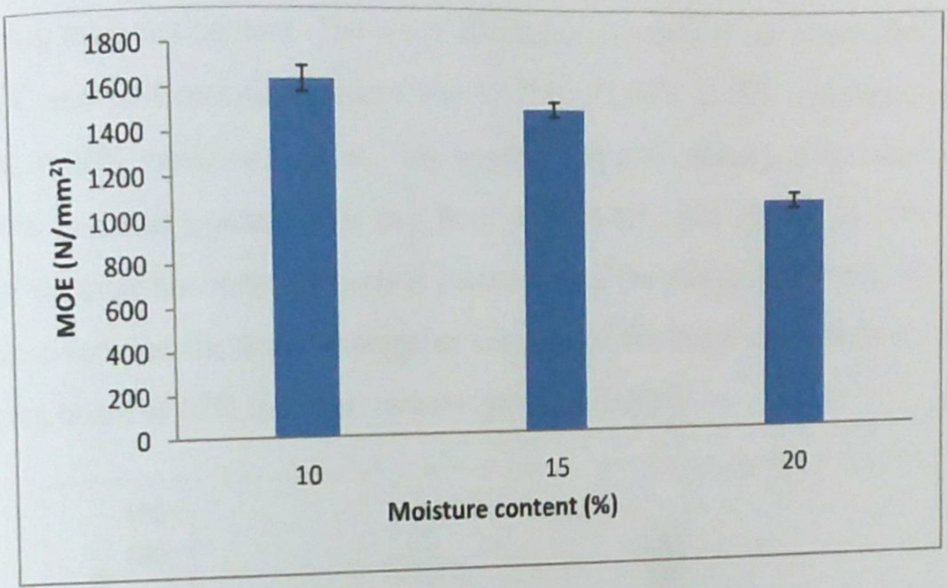


Fig.4.3.1.2 Effects of moisture content on modulus of elasticity of dhaincha binderless particleboard at 200^0C temperature

The MOE of medium density particleboard was 1725 N/mm^2 (ANSI A208.1-1993). The modulus of elasticity of the board at 200^0C and 10% moisture content was higher than 15% and 20% moisture content. The modulus of elasticity value of 10% moisture content treated board satisfies the standard value of ANSI. The modulus of elasticity was low in case of 15% and 20% moisture content boards. Because here internal self-bonding was low, it may be the low contribution of cellulose as well as lignin. The MOE of the binderless boards is also affected by the moisture content present in the particles (Widyorini *et al.*, 2011). As explained earlier that four factors (Pretreatment temperature, pressing temperature, initial pressing time and initial pressure) are significantly important affecting mechanical properties of the boards. A suitable combination of processing factors is the key to obtaining the desired properties.

4.3.2 Dimensional stability

4.3.2.1 Water Absorption

Water absorption is also an important parameter that increases with increasing moisture content. Fig. 5.2.1 shows that the water absorption capacity is increasing with increasing moisture content. The water absorption capacity of the board after half hour at 200^{0}C and 10% moisture content was 33.75%, 72.44% at 15% moisture content and 160.5% at 20% moisture content. The water absorption capacity of the board at 200^{0}C and 10% moisture content after two hour was 46.73% and 79.07% at 15% moisture content whereas the water absorption percentage of the market board was 40.12%. We also observed that the water absorption capacity of the board after 24 hours. After 24 hours the board at 10% moisture content was delaminated.

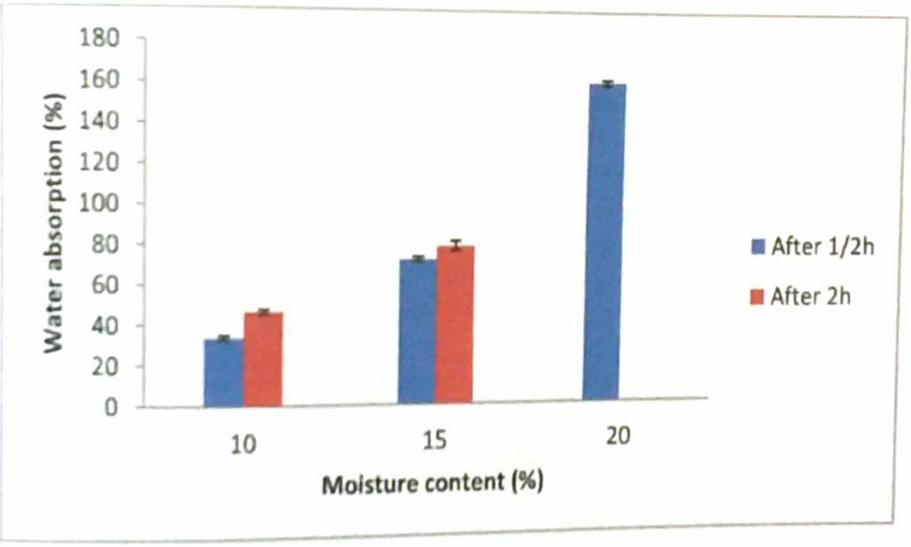


Fig.4.3.2.1 Effects of moisture content on water absorption of dhaincha binderless particleboard at 200^{0}C temperature

The maximum water absorption was found in 20% moisture content board. Because here the gaps and flaws at the interfaces is higher than other boards as well as the presence of higher amount of hemicelluloses. Here, moisture content percentage is mainly responsible for the water absorption capacity of the board. The higher amount of hemicelluloses content in dhaincha may lead to the higher affinity to moisture. In the case of fiberboards, the dimensional stability of the fiberboards is related to partial hemicelluloses hydrolysis because hemiocelluloses are very hydrophilic (Arias, 2008).

4.3.2.2 Thickness Swelling

The moisture content has an important effect on thickness swelling that increases with increasing moisture content. Fig. 5.2.2 shows the effects of moisture content on thickness swelling of dhaincha binderless particleboard at 200^{0}C temperature. The thickness swelling percentage of the board at 200^{0}C and 10% moisture content after half hour was 22.82%, 38.95% at 15% moisture content and 105.31% at 20% moisture content. The thickness swelling percentage of the board at 200^{0}C and 10% moisture content after two hour was 28.54%% and 42.43% at 15% moisture content. The thickness swelling percentage of the market board was 20%. We also observed the thickness swelling percentage of the board after 24 hours. After 24 hours the board at 10% moisture content was delaminated.

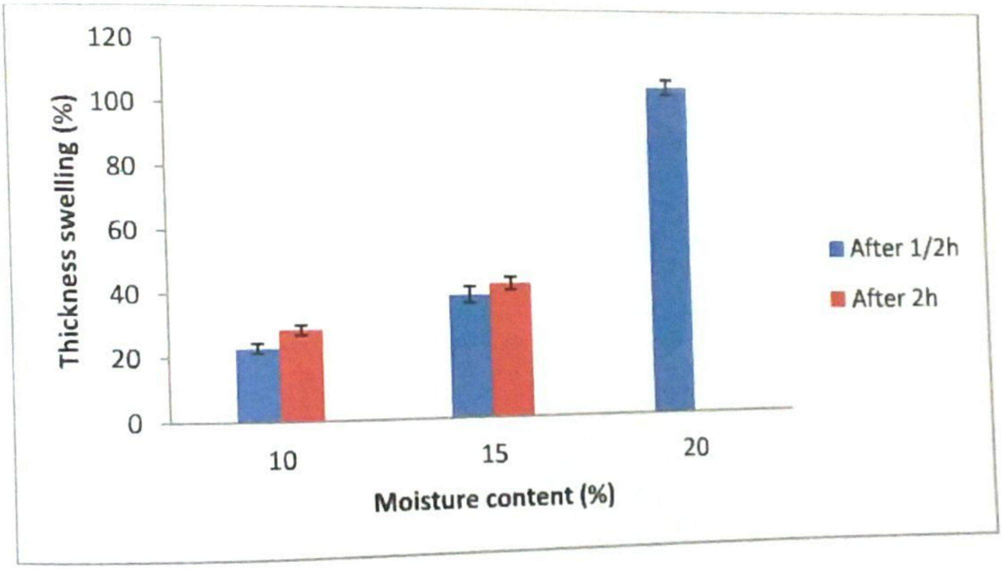


Fig.4.3.2.2. Effects of moisture content on thickness swelling of dhaincha binderless particleboard at 200^{0}C temperature

The thickness swelling percentage is higher at 20% moisture content board as well as the thickness swelling percentage was comparatively higher than the market boards. Because here the gaps and flaws at the interfaces is higher than other boards as well as the presence of higher amount of hemicelluloses. Here, moisture content percentage is mainly responsible for the thickness swelling percentage of the board.

CHAPTER 6

Conclusion

The study aimed to develop binderless particleboard from dhaincha sticks. Binderless particleboard was successfully developed from dhaincha sticks with 200^0C temperature at 10% moisture content and 10 min pressing time. The modulus of rupture of the board was 11.67N/mm^2 whereas the modulus of elasticity was 1633.84N/mm^2. Hence, Dhaincha binderless board showed good mechanical properties and these result satisfy the standard value of ANSI. However, water absorption and thickness swelling percentages of the boards are comparatively higher. Further study is required to optimize the parameters for improving the board properties.

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