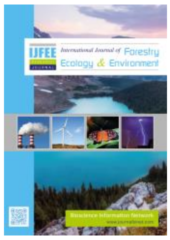
Published with Open Access at Journal BiNET
Vol. 03, Issue 02: 130-134
International Journal of Forestry, Ecology and Environment
Journal Home: https://www.journalbinet.com/ijfee-journal.html



Suitability of rubber tree (*Hevea brasiliensis*) for making hardboard

Nazma Khatun, M. Misbahuddin, Daisy Biswas and Urbashy Roy

Bangladesh Forest Research Institute, P.O.: Box 273, Chattogram-4000, Bangladesh.

*Corresponding author: nazma.bfri@gmail.com (Khatun N); Contact no: +8801722779567
Article received: 11.03.21; Revised: 23.03.21; First published online: 31 March 2021.

ABSTRACT

Rubber (Hevea brasiliensis) wood (stem and branch) chips were pulped to produce hardboard for industrial use. Hardboards were made by thermo mechanical (steaming) and chemo mechanical processes for making hardboard to assess their suitability. In the thermo mechanical process, chips under 7.03 kg/cm² and 10.55 kg/cm² digester pressure each for 30, 60 and 90 minutes. In the chemo mechanical (chemical pre-treatment) process, chips were soaked in 1, 2, 3% NaOH solution under atmospheric pressure at 24 hours soaking time. Hardboards were tested to determine their modulus of rupture and water resistance properties. Results showed that chemically treated boards are stronger than steam softening boards. The boards made from rubber branches are much stronger than rubber stems.

Key Words: *Branch, Chemo mechanical, Hardboard, Thermo mechanical, Rubber wood and Stem.*

Cite Article: Khatun, N., Misbahuddin, M., Biswas, D. and Roy, U. (2021). Suitability of rubber tree (*Hevea brasiliensis*) for making hardboard. International Journal of Forestry, Ecology and Environment, 03(02), 130-134.
Crossref: https://doi.org/10.18801/ijfee.030221.14

I. Introduction

Rubber tree (*Hevea brasiliensis*) has an essential role as an industrial crop in more than 40 countries globally, including Bangladesh, for its latex production (Venkatachalam et al., 2006). Rubber trees were introduced in Bangladesh in 1952 from Malaysia and Sri Lanka. Those were established on a new source in Chattogram and Madhupur (Tangail) region. In 1960 the Department of Forest of Bangladesh took up an experimental project, 'Rubber Plantation Programme' based on the recommendation of rubber experts of Food and Agriculture Organization (FAO) of the United Nations (UN). In 1962, the Forest Industries Development Corporation (BFIDC) implemented a project. BFIDC estimated that 3.5 million rubber trees were present at their rubber orchards in different parts of Bangladesh. Among them, about 2 million rubber plants were able to produce latex. BFIDC's annual production of rubber went up to 6,100 metric tons per year. Private sector gardens also produced yearly about 5,500 metric tons. The rubber plant's average life is generally 32 to 34 years. Rubber trees are harvested when tapping becomes uneconomical. After losing productivity of latex, the old trees are replaced by new plantations. Each tree provides 5 to 8 cubic feet of merchantable wood. The timber is good, straight-grained and pale yellow to white in color, alike to the Civit (*Swintonia*

Published with open access at journalbinet.com.
EISSN: 2708-5430,

floribunda) or Champa (*Michelia champaca*), with a specific gravity of 0.56 (Mohd Nor, 1999). In rubber wood, sapwood and heartwood are indistinguishable by colour (Killmann et al., 2000). Density of rubber wood is medium (air-dry density 560–650 kg/m^3) timber and suitable for a wide scope of applications (Killmann, 2001). 15 lesser used / unused medium density wood was studied to determine their hardboard making characteristics (Shafi and Khan, 1999). Commercial utilization of rubber wood was started after the 1970's (Jahan et al., 2011). In India, Sri Lanka, Malaysia and Indonesia, rubber wood is used for house construction, furniture, etc. (Akhter et al., 1994). The little size logs or branches are used for particleboard, plywood and medium density fiberboard (Zhang et al., 2008). In the near past, rubber wood was used as burning fuel in Bangladesh. Now the rubber wood has turned into a valuable timber for making furniture and this has been made possible due to a technology developed by the researchers of Bangladesh Forest Research Institute (BFRI). BFRI has been investigated its end uses. After that, hardboard manufacturing study was taken on observing the suitability of this species.

II. Materials and Methods

Wood collection and chips making

The stem and branches of freshly cut 33 years rubber trees were collected date on 29.08.2016 from Datmara Rubber Estate, Fatikchhari, Chattogram with bark on. The stem and branches were disembarked and chipped distinctly by a laboratory model Murray chipper machine. The chips were separated to eliminate over size and pinch chips. The average dimensions of chips were nearly 20 mm, 10 mm and 3 mm in length, width and thickness, respectively. The chips were then aired desiccated and kept in a wrapped polythene sack for pulping. The study was conducted from 2016-2017 in the pulp and paper laboratory.

Pulping process

Pulping was done in two methods, namely- thermo mechanical and chemo mechanical process.

Thermo mechanical pulping: In the thermo mechanical process, the sorted chips were cooked in two different temperatures by steam in a laboratory model stainless steel rotary digesters at 164 and 181°C where the inside pressures were 7.03 and 10.55 kg/cm^2, respectively. The cooking time for each sample was 30, 60 and 90 minutes. The chips were then refined in a single rotating disk attrition mill at different plate clearances of 10, 15 and 20 milling points. Three pulps of different freeness were made from each cook. The process was replicated for stem and branch chips. In this process, 18 pulps samples for stem chips and 18 pulp samples for branch chips were produced for further testing.

Chemo mechanical pulping: In the chemical pre-treatment process, the sorted chips were soaked in 1, 2 and 3% NaOH aqueous solution for 24 hours under atmospheric pressure. The chips were then refined in a single rotating disk attrition mill at different plate clearances of 10, 15 and 20 milling points as was done for the mechanical pulping process. Three pulps of different freeness were produced from each chemical treatment. This chemical process was replicated for stem and branch chips. Nine pulps samples for stem chips and nine pulp samples for branch chips were produced for further testing in this process.

Hardboard preparation

For the preparation of the hardboard, at first, 10 liter volume of slurry was made from 128 g oven dry pulp in water. Pulp freeness was recorded in the freeness tester each time. Mat was formed after dewatering water from the freeness tester. The mat was then pressed into a cold press to reduce the thickness and remove excess water to moisture content to 60%. Finally, the cold-pressed mat was compressed between the cauls of a hydraulic hot press at about 190°C. The pressing time was six minutes, where the first two minutes pressure was 35 kg/cm^2, then one minute breathing at 7 kg/cm^2 and last three minutes again pressed at 35 kg/cm^2. Thus S-1-S (smooth on one side) hardboards were made.

Board testing

Five boards of each pulp were prepared for sampling in size 12.7 cm x 5.08 cm. Three samples were obtained from each board. Test samples were kept in a condition room at 50 ± 2% relative humidity and 23 ± 1°C temperatures. Then one sample from each board was tested to static bending for

Published with open access at journalbinet.com.
EISSN: 2708-5430,

determining MOR according to ASTM (D1037-52T) procedures (Annon, 1954). Another such specimen was tested to determine water absorption and thickness swelling. Water absorption tests were done by keeping samples 2.54 cm deep underwater for 24 hours in a horizontal plane.

III. Results and Discussion

Quality of prepared hardboard

Five boards modulus of rupture (MOR) values of each pulp of rubber (stem and branch) were evaluated and average values were calculated (Table 01). The MOR values are plotted against the pulp freeness (Figure 01) to get MOR values at 25 freeness for comparison. The freeness value range of rubber stem pulp is 18-40 seconds and rubber branch pulp is 18-28 seconds for steam softening chips and for chemically treated chips, the value range is 29-63 seconds of rubber stem pulp and 24-30 seconds of rubber branch. Pulp freeness is an important consideration in the manufacturing process, and a freeness value exceeding 40 seconds (defibrator freeness) is ordinarily unacceptable for the industrial purpose (Lyall, 1969).

Table 01. Strength properties of steamed and pre-treatment hardboard made from rubber wood (stem and branch) chips

Cooking condition		Freeness in seconds		Modulus of rupture (MOR) kg/cm^2		MOR interpolated at 25 seconds	
Digester pressure (kg/cm^2)	**Steaming time (minute)**	**Rubber stem**	**Rubber branch**	**Rubber stem**	**Rubber branch**	**Rubber stem**	**Rubber branch**
		18	20	29	117		
	30	20	23	37	172 A	53.04 D	164 A
		23	26	46	160 A		
		19	20	46	189 A		
7.03	60	20	20	71	223 A	79.51 C	243.50 A
		27	24	86	236 A		
		34	18	135	69		
	90	37	19	143	136	109.33 B	181.33 A
		40	20	152 A	96		
		25	25	176 A	242 A		
	30	29	26	168 A	201 A	165.14 A	216.56 A
		31	28	240 A	297 A		
		24	20	195 A	262 A		
10.55	60	24	20	216 A	246 A	206.80 A	
		19	21	199A	189 A		
			19		52		
	90	-	20	-	134	-	257.83 A
			21		115		
		49	27	124	364 A		
1% NaOH	-	53	28	143	401 A	46.63 D	401.42 A
		63	30	153 A	345 A		
		30	26	135	292 A		
2% NaOH	-	34	27	141	332 A	125.89 B	306.50 A
		48	29	166 A	303 A		
		29	24	133	286 A		
3% NaOH	-	37	24	135	340 A	130.47 B	342.67 A
		56	27	145	402 A		

Modulus of rupture of the board made from rubber stem are 29-152 kg/cm^2 at 7.03 kg/cm^2 digester pressure and 168-216 kg/cm^2 at 10.55 kg/cm^2 digester pressure. These values for rubber branch are 69-236 kg/cm^2 and 52-297 kg/cm^2 at the respective digester pressure. Whereas 124-166 kg/cm^2 and 286-402 kg/cm^2 for chemically treated rubber stem and branch pulp. Modulus of rupture (MoR) value >150 kg/cm^2 is A grade and <60 kg/cm^2 is D grade (Shafi and Khan, 1999). It is observed that boards made from both steam softening and chemically treated rubber branch pulps are A grade. It also observed that high digester pressure is needed to get A grade board from rubber stem pulp. Rubber stem is wounded at the time of latex collection, so fiber of stem is damaged on the other hand, fiber of branches will remain unchanged.

Published with open access at journalbinet.com.
EISSN: 2708-5430,

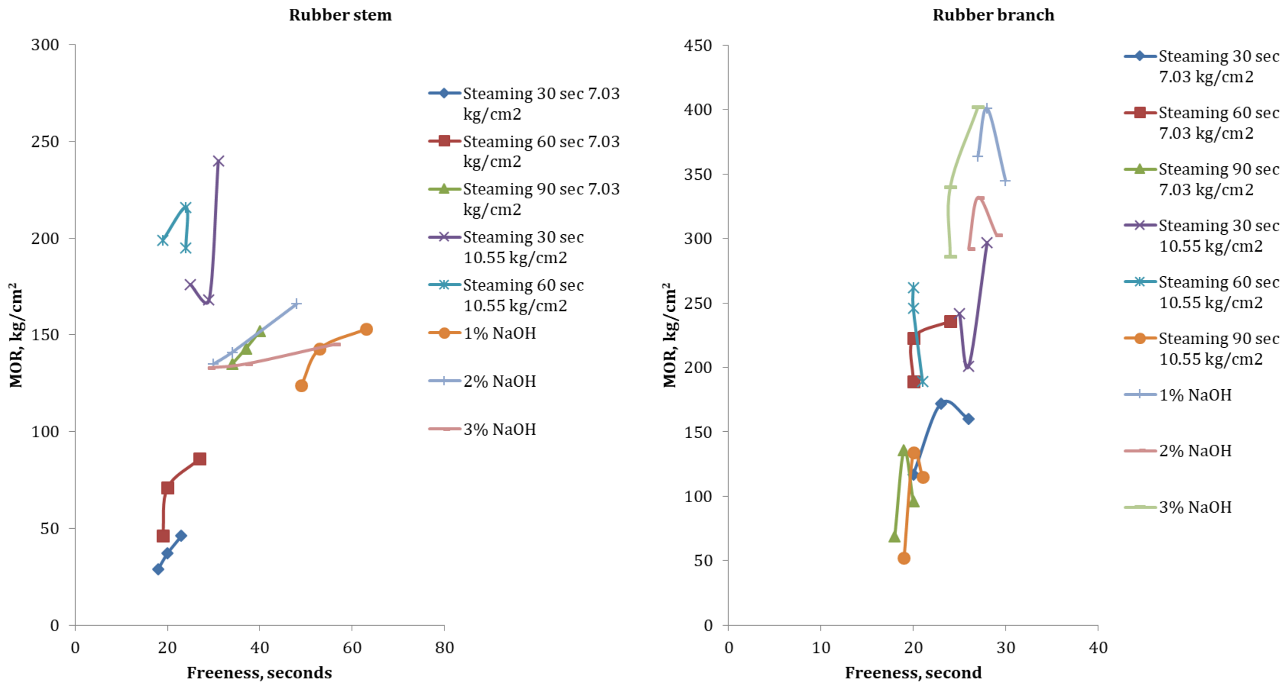


Figure 01. Modulus of rupture of hardboard made with rubber (stem and branch) wood chips steaming and pre-treated with different chemicals versus pulp freeness

Table 02. Water resistant properties of steamed and pre-treatment hardboard made from rubber wood (stem and branch) chips.

Cooking condition		Freeness in seconds		Water absorption (%)			
				Change in weight		Change in thickness	
Digester pressure (kg/cm^2)	Steaming time (minute)	Rubber stem	Rubber branch	Rubber stem	Rubber branch	Rubber stem	Rubber branch
7.03	30	18	20	85 D	76 C	67 D	53 D
		20	23	59 B	43 A	30 A	20 A
		23	26	73 C	72 C	46 C	36 B
	60	19	20	62 B	97 D	26 A	56 D
		20	20	48 A	88 D	27 A	58 D
		27	24	53 A	82 D	67 D	64 D
	90	34	18	47A	88 D	28 A	92 D
		37	19	51 A	100 D	34 B	53 D
		40	20	54 A	137 D	24 A	64 D
10.55	30	25	25	77 C	59 A	39 B	30 A
		29	26	70 B	57 A	44 C	28 A
		31	28	37 A	50 A	20 A	29 A
	60	19	20	84 D	74 C	57 D	44 C
		24	20	83 D	69 B	55 D	49 C
		24	21	82D	79 C	52 D	45 C
	90		19		111 D		38 B
			20		107 D		71 D
			21		102 D		64 D
1% NaOH	-	49	27	62 B	54 A	38 B	36 B
		53	28	55 A	61 B	34 B	33 B
		63	30	74 C	64 B	48 C	41 C
2% NaOH	-	30	26	79 C	70 B	51 D	43 C
		34	27	77 C	68 B	51 D	41 C
		48	29	52 A	70 B	28 A	43 C
3% NaOH	-	29	24	86 D	66 B	50 C	46 C
		37	24	53 A	69 B	31 B	43 C
		56	27	61 B	48 A	34 B	29 A

Water resistance is another important property expressed in terms of the amount of water absorbed by them and their thickness swelling. The result of water absorption and thickness swelling are

Published with open access at journalbinet.com.
EISSN: 2708-5430,

expressed (Table 02). Water absorption range of the board made from rubber stem and rubber branch are 37-85% and 43-137%, respectively for steaming pulp. The chemically treated water absorption range of the board rubber stem and rubber branch are 52-86% and 48-70% gradually. Thickness swelling properties range of the board made from rubber stem and rubber branch are 20-67% and 20-92% respectively for steaming pulp. Chemically treated thickness swelling properties ranges of the same boards are 28-51% and 29-46% in the same respects. Change in weight <60% and change in thickness <30% make A grade water resistant hardboard and >80% weight and >50% thickness change make D grade water resistance properties of hardboard (Shafi and Khan, 1999). At lower steaming time structure of chemical compositions of rubber wood are no changes. At higher steaming time structure of lignin, hemicelluloses, extractive and alpha cellulose are changed. So at the lower steaming time, A grade hardboard was made.

IV. Conclusion

Pulp freeness value of rubber wood (stem and branch) have industrially acceptable limits for steamed cooked chips but rubber stem pulps are exceeding freeness value for chemically treated chips. With the increase of digester pressure and steaming time rubber wood board's strength is increased. It is also seen that strength properties (MOR) is increased with increasing the chemical concentration. Excellent quality boards are formed by chemically treated rubber branch pulp. Water resistance properties of rubber branch boards are much better than the board made from rubber stem pulp.

References

[1]. Akhter, K., De, B. C. and Younus-uzzaman, M. (1994). Natural Durability and Treatability of Rubber (*Hevea brasiliensis*) wood. Bangladesh Journal of Forest Science, 23(2), 74-78.

[2]. Anonymous (1954). Evaluating Properties of Building Boards, D-1036-52T. ASTM.

[3]. Jahan, M. S., Haider, M. M., Rahman, M., Biswas, D., Misbahuddin, M. and Mandal, G. K. (2011). Chemical pulping: Evaluation of rubber wood (*Hevea brasiliensis*) as a raw material for kraft pulping. Nordic Pulp & Paper Research Journal, 26(3), 258-262 https://doi.org/10.3183/npprj-2011-26-03-p258-262

[4]. Killmann, W. and Hong, L. T. (2000). Rubber wood – the success of an agricultural by-product. Unasylva, 51(2), 66–72

[5]. Killmann, W. (2001). Non-forest tree plantations. Forest Plantations Thematic Papers, Forestry Department, Food and Agriculture Organization of the United Nations

[6]. Lyall, J. D. (1969). Structural board. Pulp and Paper Manufacture, Vol. II (2nd Edition). Ed. Ronald G. Medonald. P. 422.

[7]. Mohd Nor, M. Y. (1999). Pulp and paper from rubber wood. In: Hong LT, Sim HC (eds) Rubber wood – processing and utilization. Forest Research Institute Malaysia (FRIM), Kepong, pp 195–202.

[8]. Shafi, M. and Khan, M. S. (1999). Hardboard making characteristics of fifteen lesser used/unused medium density hardwood species of Bangladesh. Bangladesh Journal of Forest Science, 28 (1), 59-63.

[9]. Venkatachalam, P., Jayashree, R., Rekha, K., Sushmakumari, S., Sobha, S., Jayasree, P. K., . . . Thulaseedharan, A. (2007). Rubber Tree (*Hevea brasiliensis* Muell. Arg). In K. Wang (Ed.), Agrobacterium Protocols Volume 2 (pp. 153-164). Totowa, NJ: Humana Press. https://doi.org/10.1385/1-59745-131-2:153

[10]. Zhang, Y., Gao, R., Zhao, Y., Feng, S., Ratnasingam J., Lu, J. and Ye, K. (2008). The Rubber wood Utilization in China, pp. 1-9, Proceedings of the ITTO/CFC International Rubber wood Workshop, Promotion of Rubber wood Processing Technology in the Asia-Pacific Region. Ed ZHAO Y. December 8-10, 2008, Haikou, CHINA.

Published with open access at journalbinet.com.
EISSN: 2708-5430,