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Investigation Mechanical Characterization of Rattan Under Chemical Treatment

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Abstract: This research is conducted to discover the comparison of the rattan condition before and after treatment is applied. Efficient design of any structural component and the strength capabilities of the material to be utilized must be known ahead of time. Rattan cane offers a challenge due to the quality that cannot be controlled as it is a naturally occurring material. All of the other structural materials are man-made, and some form of quality control can be conducted during their manufacturing. This has resulted in some scientific work on the structural qualities of rattan cane. The study was concentrated on one of the features of rattan rods by examining the effects of rattan rod moisture content during or after modifications or treatments. In which have been structurally coated with mechanical parameters such as the tensile strength on the surface of the rattan rod. The rattan was implemented after the treatment in the shape of a finishing product to see its reliability and durability compared to the other material product in the market.

Keywords: Rattan, Mechanical, Rattan Properties, Mechanical Test

1. Introduction

Rattan is a natural resource found in areas where rainforests prevail, such as Asia and Africa. Many countries are developing countries with economic development needs, and they rely on rattan exports like crafts and wicker furniture as part of their economic strategies. As we all know, rattan is in high demand, particularly in the handicraft and art industries (2011, Hurt).

Rattan is commonly used in the production of baskets and furniture. Rattan, when cut into pieces, can be used to make furniture as a piece of wood. Like many other types of wood, rattan absorbs paints and stains, so it comes in a variety of colours and can be used in a variety of ways. Most rattans are distinguished from other palms by their slender stems, which are 2-5 cm (3-4 inches) in diameter and have long stems between the leaves; they are also not trees but vine-like lianas that scramble through and over other vegetation (Rachchh et al., 2014). Rattans, like bamboo, have a similar appearance. It can affect the growth Rattan industry because no specification can make sure the rattan is safe to use.

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This research aims to examine the mechanical properties of rattans to obtain the characteristic of rattan after chemical treatment. The test will be carried out based on different type of chemical treatment. Then we need to test the reliability and durability of the rattan after the finished product.

The rattan industry in Malaysia is slightly down than in other Asian countries. Malaysia is one of the essential rattan processes in the world. In the rattan industry, the country is undergoing robust growth. This product plays a significant role in the economic growth of Malaysia. In this industry, there are a few processes or techniques that are vital. Malaysia is second in the ranking for the rattan industry after Indonesia. (Wahab, Mokhtar, et al., 2019). In the rattan industry, many standards can make sure the rattan can be produced with high quality and make sure that the furniture industry's committee approves rattan. They already have their rattan and wicker furniture standards, much like nearby countries like the Philippines and Indonesia. This standard includes all the specifications for rattan furniture production, such as manufacturing products, the materials to be used for finishing, sampling, and even the form of mechanical tests to be carried out on the furniture.

2. Materials and Methods

By referring to previous studies, the flow of the experiments and methods used are explained. The identification of mechanical properties can be divided into three stages: material preparation, experimental setup, and finally, rattan property analysis.

2.1 Initial Processing

According to Palisoc, et al. (2004), Small-diameter canes are then smoked in sulphur-burning Small-diameter canes are then smoked in sulphur-burning cabinets, shielded from rain, for at least 12 to 24 hours. Bleaching rattan with sulphur is the next move. These processes aim to conserve rattan, release the best colour, and protect rattan from pests and fungi. Larger canes are boiled in a mixture of diesel oil, kerosene and other ingredients for 20 to 60 minutes. They are then stacked at a slant or rubbed with sawdust to remove excess oil and air-dried in an upright position for 5 to 14 days. The big canes are sometimes bleached. These processes are intended to conserve rattan, as in small rattan, releasing rattan's best colour and preserving it from pests and diseases.

The chemical treatment improves the surface roughness of the fibre surface by removing the lignin, hemicellulose, wax, and oils that cover the fibre's exterior surface, thereby strengthening the bond between the fibre and matrix. To solve the durability issue associated with natural fibres in polymer-based composites thorough understanding of the degradation mechanisms of the fibres in the matrix is required

2.2 Methods

2.2.1 Analysis Data

The Each cane was divided into several height intervals, with five interns in each height interval numbered from the base to examine the longitudinal variations of the cane. If the internode has been bent or damaged, it will be replaced with another rattan. We used a Universal testing machine to test the tensile strength following ASTM D-638 standards (Rachchh et al., 2014). This standard can be used to test the rattan's mechanical strength.

According to (Yang et al., 2020), Analysis data is essential in this research because we can get the specific result of the rattan after the treatment to see whether the treatment will affect the toughness of the rattan. The data set contain of tensile strength (TS), tension modulus (TM), compressive strength (CS), toughness of the IT effect, rupture modulus (MOR), and elasticity modulus (MOE). Included all the force of torsion, and the data will be tabulated in the form of a graph.

Table 1: The data collected after the testing (Yang et al., 2020)

Species	Tensile strength (MPa)	Modulus of tension (MPa)	Compression strength (MPa)	Impact toughness (J/ 〖cm〗 ^2)	Modulus of rupture (MPa)	Modulus of elasticity (MPa)
C. simplicifolius	41.99	1897.01	24.93	23.01	54.13	1303.36
C. nambariensis var. yingjiangensis	44.74	2315.46	26.01	53.81	63.38	1173.54
C. nambariensis var. xishuangbannaensis	43.94	2212.15	25.07	22.56	67.64	1816.34
C. yunnanensis	57.21	2514.2	27.75	23.82	72.32	2150.29

2.2.2 Modulus Elasticity

The elastic modulus measures the resistance of a material to non-permanent or elastic deformation. Materials will first exhibit elastic properties when under stress: stress causes them to bend, but once the stress is removed, the material will return to its previous state.

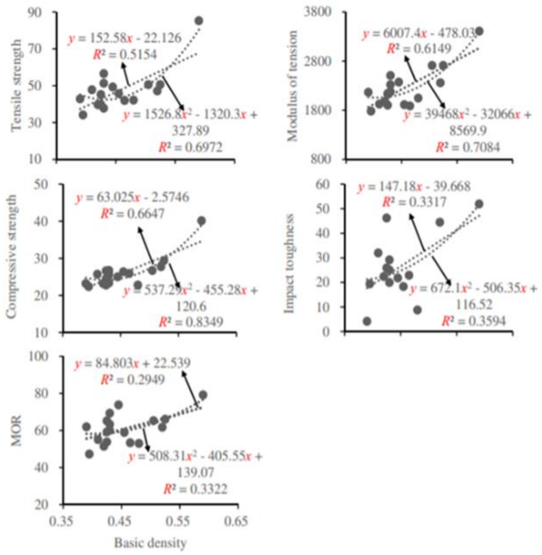


Figure 1: the tabulate date (Yang et al., 2020)

3. Results and Discussion

3.1 Tensile test

According to Gebreyohannes, et al. (2019), the tensile test was conduct by using varnish and primer paint. The testing was conduct by using universal testing machine too see its reliability and durability of the rattan after treatment.

Table 2: Water content determination for untreated rattan cane samples (Gebreyohannes, et al. (2019))

No	Parameters	Trial (1)	Trial (2)	Trial (3)
1	Initial Weight(W1) in grams	5.8	5.6	6.0
2	After Keeping in Oven(W2) in grams	5.0	4.9	5.25
3	Moisture Content (W1-W2)/W2 * 100%	16	14.26	14.24
Average Moisture Content			14.83	

The following tables show the results of moisture content in three different trials. The three-specimen contains five rattan cane stick lengths of 25 mm to get correct data for further analysis as observed in the laboratory conduction session. As a result, the average moisture content of rattan cane is 14.83% (untreated rattan).

Moisture Content = $\frac{W_1 - W_2}{W_2}$ X 100
-W_1 is initial weight
-W_2 is moist weight

Thus, the moisture content for three groups of Vittayila Calamus species Rattan cane of length 25 mm is 14.83% before any chemical was painted on the surface of the rattan cane specimen.

Table 3 Determination of water content for treated rattan cane Varnish painted rattan

(Gebreyohannes, et al. (2019))

No	**Parameters**	**Trial (1)**	**Trial (2)**	**Trial (3)**
1	Initial Weight(W1) in grams	6.1	6.0	6.2
2	After Keeping in Oven(W2) in grams	5.50	5.30	5.00
3	Moisture Content (W1-W2)/W2 * 100%	10.31	13.30	12.73
Average Moisture Content			12.14	

The result show 12.14% indicates that the moisture content of rattan will decrease by 2.69% from 14.83% when it is untreated or unpainted.

Table 4 Chemically painted rattan cane with wood primer (Gebreyohannes, et al. (2019))

No	Parameters	Trial (1)	Trial (2)	Trial (3)
1	Initial Weight(W1) in grams	6.60	7.25	6.60
2	After Keeping in Oven(W2) in grams	6.00	7.50	6.00
3	Moisture Content (W1-W2)/W2 * 100%	10.00	11.54	10.00
Average Moisture Content (gram)			**10.52**	

The result of 10.52% declares that there will be a decrease in rattan moisture content of about 4.31% from 14.83% initially at its untreated or unpainted stage, which is a comparably good result. It also shows that the wood primer solution chemical is effective in reducing water content.

Primer chemical treatment or modification is more likely preferable due to its lower effect and lower observed results than varnish paint treatment. Thus, it is preferable to use the wood primer for the rattan as an alternative to steel. It operates as reinforcement to avoid failures in terms of corresponding mechanical strength parameters that can be negatively affected by changes in moisture or water content in the composition of the rattan cane in use.

3.2 Strength of Rattan Before and After treatment

Based on previous study Gebreyohannes, et al. (2019), the rattan was testing their strength by using universal testing machine. Then the calculation is to see the actual tensile strength after the treatment.

Table 5 Tensile Strength of Untreated and Varnish Painted Rattan Cane Samples (Gebreyohannes, et al. (2019))

	Tensile Strength in, MPa	
No.	**Untreated**	**Treated**
1	130	165
2	135	172
3	142	175
	Average=135.7	Average=170.6
	Percentage increase in tensile strength = 25.7%	

As a result, using rattan cane that has been painted with a Varnish chemical solution can increase tensile strength performance by a quarter, or 25.7%. This result is improved due to a decrease in moisture content within 48 hours of drying after painting. It also enhances the chemical's ability to protect against exposures, insects, and fungicides due to its good composition.

Table 6 Tensile Strength of Untreated and Primer Painted Rattan Cane Samples (Gebreyohannes, et al. (2019))

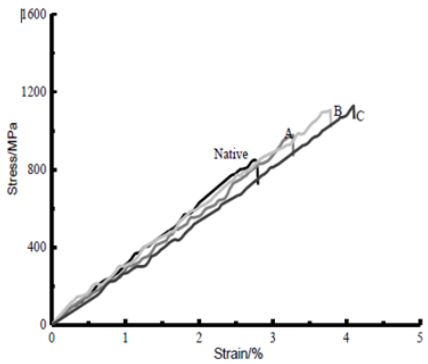
	Tensile Strength in, MPa	
No.	**Untreated**	**Treated**
1	130	189
2	135	192
3	142	195
	Average=135.7	Average=192
	Percentage increase = 41.86%	

This reduction in water content resulted in a 41.86% increase in tensile strength, which is very exciting for the species of rattan to be used in large numbers and more significant quantities. This amazing result is due to the chemical's ability to reduce moisture content within 48 hours of drying after being painted and its ability to protect against exposures, insects, and fungicides due to its good composition.

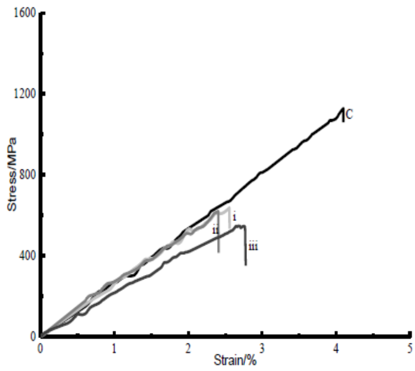
As a result, wood primer chemical is preferred because of its superior effect as evidenced for better results than varnish paint. As a result, it is preferable to use or adopt primer to use rattan as an alternative to steel as a reinforcement with greater confidence in not being exposed to the phenomenon of tensile strength parameter failures.

3.3 Impact of Chemical Use on The Material's Strength

According to (Lazic B.D. *et al*, 2016), the severity of treatment is generally defined by weight loss caused by removing hemicelluloses and lignin (and other minor constituents) from flax fibres. Figures a and b show that as the concentration of the modification agent (NaOH or NaClO2) increases, so does the weight loss of the flax fibres, whereas increasing the treatment time has a smaller effect on the weight loss. Curves of stress and strain Figure a depicts the typical stress-strain curves of single fibres after various treatments. All of the fibres tested demonstrated a linear stress-strain behavior to failure, indicating that changes in chemical components did not affect the tensile behavior of single fibres.



(a) delignified treatments



(b) hemicelluloses-extracted treatments

Figure 2: after various treatments, typical stress-strain curves of single fibres (Lazic B.D. *et al*, 2016)

3.4 Effects of Different Bleaching Conditions on Bending

According to (Devera et al., 2009), The rattan poles' moisture content ranged from 8 to 12% at the time of bleaching. The colour of the rattan poles changed significantly after bleaching. Sika and palasan that had not been bleached were pale or light brown, whereas bleached poles were whitish. All bleaching agents, soaking time, and temperature combinations resulted in whiter rattan poles. Figures 3 and 4 show the different sika and palasan samples following the bending test, respectively. The topmost samples in Figure 3 represent the sika poles that failed the bending test quickly. The samples in the middle did not fail even when tested on the smallest jig. The bottom samples are sika poles that were not bleached but failed at an average radius of 10.67 mm despite not being bleached.

Figure 3: Images of bent bleached sika poles showing samples that readily failed (topmost), samples that did not fail (middle), and unbleached controls (bottom) (Devera et al., 2009)

Figure 4: Pictures of bent palasan poles showing bleached poles that did not fail (topmost), those that did fail (middle), and an unbleached control (bottom) (Devera et al., 2009)

The highest samples in Figure 4.11 are the palasan poles that did not break after being bent with the smallest jig. The samples in the centre failed in the jig with a radius of 127 mm. On the surfaces of the samples, cracks or ruptures can be noticed. The bottom samples are palasan canes that were not bleached and failed with an average radius of 84.58 mm.

The minimum radius at which sika could be bent without breaking was 6.35 mm, while palasan's radius was 44.45 mm. The unbleached sika (control) would fail between the fifth and sixth (smallest) bending jigs, for a total of six bending jigs (Tables 4.6 and 4.7). Failure for palasan would occur between the 11th and 12th bending jig, out of a possible total of 18 bending jigs utilized in the test. The bleaching treatment had the minor effect on the bending tolerance of sika samples soaked for 1 hour at 60° C in bleaching solution 2. Even when bent with the shortest radius of 6.35 mm, the samples did not fail. The most negatively damaged samples by bleaching were those that had been soaked for two hours in bleaching solution 1 at 100°C. The existence of tiny cracks on bent samples was utilized as an indicator of failure at a radius of 19.05 mm.

Radius of curvature of Sika (mm)	Radius of curvature of Palasan (mm)
6.35	44.45
12.70	50.80
19.05	57.15
25.40	63.50
31.75	69.85
38.10	76.20
	82.55
	88.90
	95.25
	101.60
	107.95
	114.30
	120.65
	127.00

	133.35
	139.70
	146.05
	152.40

Table 7: The radius of curvature for the two rattan species (Devera et al., 2009)

		The minimum radius of curvature (mm)
Sika	1	19.05
	2	12.70
	3	19.05
Palasan	1	88.90
	2	88.90
	3	95.25

Table 8: The minimum radius of curvature of unbleached (control) sika and palasan (Devera et al., 2009)

4. Conclusion

In conclusion, Certain materials' mechanical characteristics are affected by chemical treatments. It impacts the rattan's tensile strength and stiffness, allowing for additional flexibility in creating rattan furniture. We can observe that the alkaline treatment is ineffective because it reduces tensile strength and removes hemicelluloses. Tensile modulus was decreased by 1.96%, 4.74%, and 5.10%, respectively, while lignin content was reduced by 11%, 25%, and 99%. On the other hand, the average tensile strength of single fibres was increased because of decreasing the lignin content after the acidic treatment. The tensile strength was increased by 26.28%, 34.22%, and 41.18%, respectively, and reduced lignin content by 11%, 25%, and 99%. Delignified fibres were treated with increasing concentrations of NaOH, which resulted in a significant decrease in tensile modulus and strength. Tensile modulus was reduced by 9.55%, 11.08%, and 11.57% for hemicelluloses extracted at 6% NaOH, 6+8% NaOH, and 6+8+10% NaOH, respectively, while the tensile strength for single fibres a was reduced by 29.36%, 30.71%, and 32.15%.

From this research, we can see that chemical treatment affected rattan's reliability and durability, especially in the form of furniture. Depending on the application, chemical treatment may have an impact on the overall performance of rattan furniture. Some furniture may require acidic treatment, while others may benefit from alkali treatment. Such as NaClO2 gives more tensile strength than NaOH treatment. But NaOH treatment gives a better tensile modulus for the rattan.

From previous studies, we can see a slightly different strength of the tensile test with other chemical treatments for the mechanical test. Such as, using rattan cane that has been painted with a Varnish chemical solution can increase tensile strength performance by a quarter, or 25.7%. Which is average tensile strength before treatment was 135.7Mpa compare to after treatment which is 170.6Mpa. At the same time, the percentage increased by 41.85% from 135.7Mpa to 192Mpa by using primer paint. From here, we can see that the difference in chemical treatment leads to a change in the mechanical properties of rattan.

By improving the development of rattan continuously, it becomes the key to achieve its ideal educational objectives. There is still a lot of room for enhancement and can be further improved in terms of their chemical reaction which is directly related to the overall strength of the rattan. There also needs further research to improve the interaction between the chemical reaction and the rattan strength. Such as conducting experiments extensively in the laboratory with various chemical reactions that can acquire more results.

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