

CHEMICAL PROPERTIES OF JUVENILE LATEX TIMBER CLONE RUBBERWOOD TREES

(Sifat Kimia Klon Kayu Getah Juvenil)

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Abstract

Latex timber clone (LTC) rubberwood trees were introduced by Lembaga Getah Malaysia (LGM) for obtaining good yield of latex as well as the quality timber. Two juvenile clones namely RRIM2009 and RRIM2024 were selected for measuring the chemical properties based on TAPPI standards and were assessed at different height levels (top, middle and bottom). These chemical properties of wood can serve as an indicator for predicting the wood behavior for specific end usage. The findings revealed that there were significant variation between the clones and the highest value was obtained at the bottom portion except for lignin content. Clone RRIM2009 exhibited higher percentage of ash content (0.80%) and lignin content (17.30%). While Clone RRIM2024 has greater value of holocellulose content (58.58%) and alpha-cellulose content (41.41%). According to the different height levels, top portion exhibited highest lignin content (17.64% for RRIM2009 and 16.75% for RRIM2024). While bottom portion exhibited highest holocellulose (58.93% for RRIM2009 and 60.56% for RRIM2024), highest alpha-cellulose (39.75% for RRIM2009 and 43.02% for RRIM2024) and highest ash content (0.85% for RRIM2009 and 0.71% for RRIM2024). As a whole, clone RRIM2024 gave higher value except for lignin and ash content compared to RRIM2009. Thus, the potential of using such LTC rubberwood trees for specific purposes is promising.

Keywords: latex timber clone, juvenile rubberwood, chemical properties, wood behavior

Abstrak

Klon kayu getah (KKG) telah diperkenalkan oleh Lembaga Getah Malaysia (LGM) bagi mendapatkan hasil lateks yang banyak dan kayu balak yang berkualiti. Dua klon juvenil iaitu RRIM2009 dan RRIM2024 telah dipilih bagi menentukan sifat-sifat kimia berdasarkan kepada piawaian TAPPI dan dinilai pada tahap ketinggian yang berbeza (atas, tengah dan bawah). Sifat kimia kayu ini boleh digunakan sebagai penunjuk dalam menganggarkan sifat kayu untuk kegunaan akhir tertentu. Keputusan yang diperolehi menunjukkan bahawa terdapat perbezaan yang signifikan diantara klon dan nilai tertinggi diperolehi pada bahagian bawah kecuali bagi kandungan lignin. Klon RRIM2009 mempunyai peratusan yang tinggi bagi kandungan abu (0.80%) dan kandungan lignin (17.30%). Manakala klon RRIM2024 mencatatkan nilai yang tinggi bagi kandungan holoselulosa (58.58%) dan alfa-selulosa (41.41%). Merujuk kepada tahap ketinggian yang berbeza, bahagian atas member nilai lignin yang tinggi (17.64% untuk RRIM2009 dan 16.75% untuk RRIM2024). Manakala bahagian bawah pula mencatat kandungan holoselulosa yang tinggi (58.93% untuk RRIM2009 dan 60.56% untuk RRIM2024), nilai alfa-selulosa yang tinggi (39.75% untuk RRIM2009 dan 43.02% untuk RRIM2024) dan nilai kandungan abu yang tinggi (0.85% untuk RRIM2009 dan 0.71% untuk RRIM2024). Secara keseluruhannya, klon RRIM2024 memberi nilai yang tinggi kecuali bagi kandungan lignin dan abu berbanding RRIM2009. Oleh yang demikian, penggunaan klon kayu getah (KKG) menjanjikan potensi bagi tujuan tertentu.

Kata kunci: klon kayu getah, kayu getah juvenile, sifat kimia, perlakuan kayu

Introduction

Rubberwood tree (*Hevea brasiliensis*) belongs to the Euphorbiaceae family and was introduced into Malaya at Kuala Kangsar, Perak on 1877 from its native country Brazil. In 1996, the latex timber clones (LTC) are introduced for plantation. The advantages of LTC rubberwood is it produces high timber volume and latex in short period of times and have the potential as raw material in the wood based industries in our country. It is the intention of the Malaysian Government to find alternative for bio-composite materials in lieu to the depleting wood resources from natural forest.

Latex timber clone has many advantages; these include fast growing as well as good yield of latex and timber volume. According to Hong, [8], the straight grain of Rubberwood makes it suitable to produce mainly furniture and other wood based product such as fiberboard. Therefore, the objective of this paper is to study the chemical properties of juvenile LTC Rubberwood trees.

Materials and Methods

The plant samples used in this study were obtained from LTC rubberwood plantation at Jengka 8, Pahang. The age of LTC rubberwood during the time of harvesting was about three to four years of age. The average height of LTC rubberwood was about 4.1 m. Two clones (RRIM 2009 and RRIM 2024) of LTC rubberwood were selected randomly and harvested. Three trees were harvested for each clone. The samples were cut into disc and the bottom portions of the tree were marked at about 30 cm, the middle was about 1.3 m at diameter breast height (DBH), and top portion are taken before the first branches.

For the chemical compounds determination, air dried rubberwood was ground to form sawdust before being sieved which passed through 40 mesh sieve and retained on the 60 mesh sieve [23]. Few analyses were conducted including Hot Water soluble, Alkali (1% NaOH) soluble, Alcohol-toluene soluble, Ash content, Lignin, Holocellulose content and α -cellulose content. The experiments on Hot Water soluble, Alkali (1% NaOH) soluble, Alcohol-toluene soluble, Ash content, lignin content, and alpha-cellulose content were conducted according to the TAPPI Standard T 207 cm-99 [19], T212 om-02 [21], T 204 cm-97 [18], T 211 om-02 [20], T 222 om-02 [22] and T 203 cm-99 [24]. Otherwise, the method developed by Wise et al. [27] had been used in the determination on holocellulose content.

Results and Discussion

The chemical compositions of rubberwood were summarized in Table 1 according to clones and height. According to the chemical analysis that had been carried out, the results showed that RRIM 2024 clone has the higher value except for ash and lignin content. While based on different height, the bottom portion gave the higher value except for the lignin content.

Table 1. Chemical Properties of Rubberwood (*Hevea brasiliensis*) according to Clone and Height.

Clone	Height	HW (%)	1%NaOH (%)	AT (%)	Ash (%)	Lignin (%)	Holo (%)	alpha- cellulose (%)
RRIM 2009	Top	6.75	20.53	4.17	0.73	17.64	56.34	36.09
	Middle	6.77	20.77	4.42	0.82	17.35	57.71	38.54
	Bottom	6.80	21.10	4.62	0.85	16.90	58.93	39.75
RRIM 2024	Top	6.84	22.24	4.21	0.68	16.75	56.15	39.60
	Middle	6.86	22.76	4.63	0.69	16.56	59.04	41.62
	Bottom	6.92	23.54	4.81	0.71	16.47	60.56	43.02

Note: Values are the average of three determinations.

HW: Hot Water Soluble, NaOH: Alkali soluble (1% NaOH); AT: Alcohol Toluene Soluble, Holo: Holocellulose

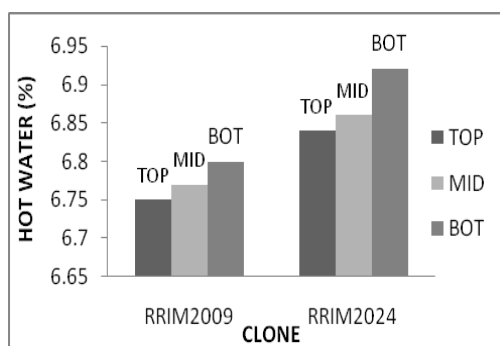
Table 2. Summary of ANOVA on the chemical properties of *Hevea brasiliensis*.

SOV	Df	HW (%)	NaOH (%)	AT (%)	Ash (%)	Lignin (%)	Holo (%)	α -cellulose (%)
Clones	1	7.85*	536.86**	3.43ns	70.35**	33.83**	716.86**	2123.62**
Height	2	1.25ns	38.19**	15.05**	12.36**	5.99*	3492.78**	838.69**

Note: SOV – Source of Variance, ns – not significant at $p > 0.05$, * - significant at $p < 0.05$, ** - highly significant at $p < 0.01$, Df – degree of freedom, HW: Hot Water Soluble, NaOH: Alkali soluble (1% NaOH); AT: Alcohol Toluene Soluble, Holo: Holocellulose

Hot Water soluble

The determination of hot water solubility of wood are referred to the material such as sugar, starch, tannin, gums and coloring matter that exist in wood. The extractive of wood and other lignocellulosic materials can be removed by extracting with a single solvent or combinations of solvents. The chemical composition of *Hevea brasiliensis* was given in the Table 1, further revealed that hot water solubility values for clone RRIM 2024 was higher than RRIM 2009 and the bottom portion for both clones also gave the higher value of hot water soluble compare to other portions. Based on the statistical analysis (Table 2), the HW solubility of rubberwood showed that, there is significant different ($r = 7.85^*$) among both clones but no significant different ($r = 1.25ns$) between the height. As pointed by Bowyer, [5] the bottom portion of trees contain sugar needed for the development of a new wood cells (Figure 1).



Note: MID – Middle, BOT – Bottom

Figure 1. Effect of hot water solubility on both clone at different height levels.

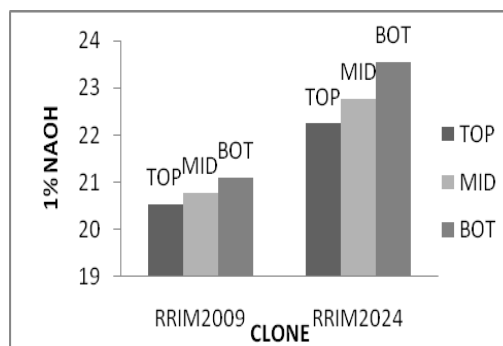


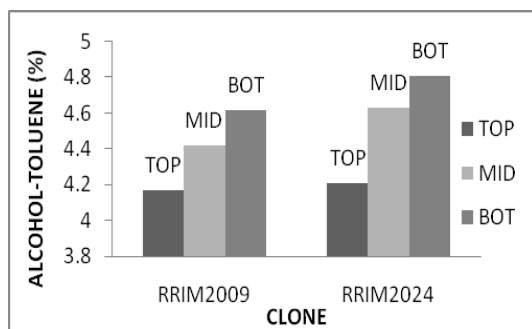
Figure 2. Effect of 1% NaOH solubility on both clone at different height level.

Alkali (1% NaOH) Solubles

The value of alkali soluble for rubberwood shows that clone RRIM2024 has a higher value compared to clone RRIM 2009. Normally, higher in alkali solubility was associated and closely related to the rate of degradation of wood [7]. According to different height levels, the value of alkali soluble decreased with increasing of height levels. Balaban and Ucar [2] said, this happen because the bottom portion has higher contained of organic acid, polysaccharides, polyphenol and tannin compared to other portion. So, this study indicated that there are highly significant effect by clones with $r = 536.86^{**}$ and height portion also gives highly significant with $r = 38.19^{**}$ (Figure 2).

Alcohol-toluene Solubles

As stated in TAPPI standard, the alcohol-toluene solubility is performed in order to determine amount of extraneous materials such as waxes, fats, resins, and certain other insoluble component so-called gums. Respectively, clone RRIM2024 gives higher percentages than RRIM2009. According to Richard [14], the functions of wood cells are for conducting sap and reinforcement but only for 14 to 21 days. After that, the wood cells will become inactive and contain a lots of extractives which principally on the bottom portion. Table 2 shows that there are no significant different on clones with $r = 3.43ns$. While the height levels are highly significant ($r = 15.05^{**}$) with increasing from top to bottom portion (Figure 3).



Note: MID – Middle, BOT – Bottom

Figure 3. Effect of alcohol-toluene solubility on both clone at different height levels.

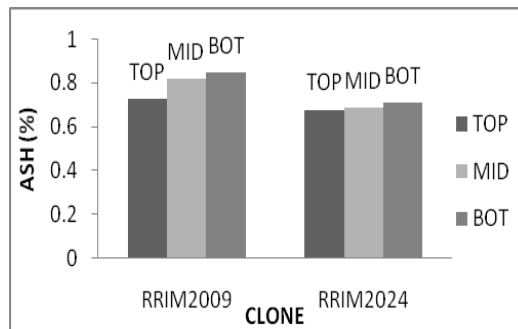


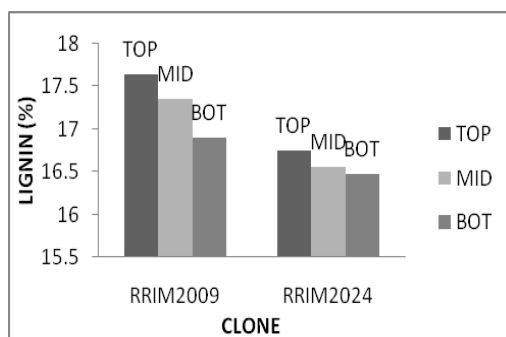
Figure 4. Effect of ash content on both clone at different height levels.

Ash Content

The ash content normally related to the amount of mineral such as silica [1]. These mineral salt and silica was found in the cell wall and lumen cell [9] and [16]. This study revealed that, clone RRIM2009 have a higher value (0.80%) of ash content compared to RRIM2024 (0.69%). On the other hand, the percentages of ash content increased from top to bottom. This is because the bottom portion contains more heartwood due to development of mature wood. According to Breness [4], the Poplar tree also showed the same trend. This is because the ash content mainly silica in the wood cells is cause by the high proportion of heartwood. High percentage of ash content is reported to be harmful to the cutting tool as mentioned by Wan Rosli [26] and Lim [12]. Table 2 shows that clones and height levels are highly significant with $r = 70.35^{**}$ and $r = 12.36^{**}$ (Figure 4).

Lignin Content

Lignin is a lignocellulosic material that functions as a binding agent which holds the individual fibers together Miller, [13]. Normally, the percentage of lignin content in hardwoods is between 19 – 25%. Result shown in Table 1 observed that lignin content tended to be higher for clone RRIM2009 (17.30%) compared to RRIM2024 (16.59%). This happen because clone RRIM2024 have thicker cell wall compared to RRIM2009. According to Saka and Goring [15], the thicker the cell wall the lower lignin content in wood. The LGM Monograph [17] noticed that clone RRIM2024 have better growth performance which distribute a higher development of mature wood compared to RRIM2009. As for the height factor, the top portion has a high value compared to bottom portion. According to Lewin [11], the top portion contains lots of new cells. Moreover, according to Bowyer [5] the lignin content is affected by the tree growth. The statistical analysis (Table 2) had further revealed that, there is highly significant different ($r = 33.83^{**}$) within the clones, while, different height level shows significant different with ($r = 5.99^*$). Furthermore, according to Via *et al.* [25], decrease in lignin content may occur as the tree matures. Raw material for paper manufacturing with lower percentages of lignin content is more favored (Figure 5).

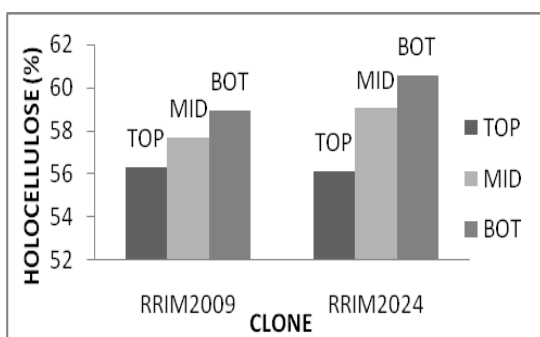


Note: MID – Middle, BOT - Bottom

Figure 5. Effect of lignin content on both clone at different height levels.

Holocellulose content

Holocelluloses consists of cellulose and hemicellulose. According to Jane [9] the composition of cellulose and lignin are closely related where the greater lignin content the lower cellulose in wood. In chemical analysis of wood, holocelluloses are soluble in 17.5% caustic soda that known as β -cellulose and γ -cellulose. As illustrated in Table 1, clone RRIM2024 had the higher value (58.58%) of holocellulose compared to clone RRIM2009 (57.67%). This is so because of its better growth performance that contributes to greater cellulose content. According to Buletin Getah Asli [6], this clone also has greater growth potential compared to clone RRIM2009. In addition, Bendtsen [3] stated that juvenile wood have advanced growth performance and higher cellulose content. Meanwhile, the percentage of holocellulose decreased along the trunk height. This phenomenon is because the top portion is active in producing new cells. Based on Table 2, clones and height levels are highly significant with $r = 716.86^{**}$ and $r = 3492.78^{**}$ (Figure 6).



Note: MID – Middle, BOT – Bottom

Figure 6. Effect of holocellulose content on both clone at different height levels.

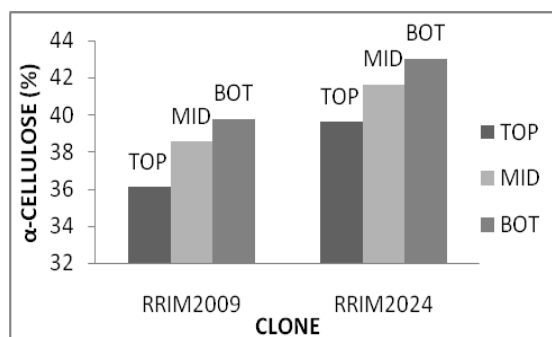


Figure 7. Effect of α -cellulose content on both clone at different height levels.

Alpha-cellulose content

Cellulose content is higher in secondary walls and it has larger molecules. According to Jane [9], α -cellulose is insoluble in 17.5% caustic soda. Clone RRIM2024 had higher value (41.41%) of alpha-cellulose because it has thicker cell wall compared to clone RRIM2009 (38.13%) (Table 1). According to Buletin Getah Asli [6], clone RRIM2024 had greater growth performance. On the other hand, the α -cellulose content is decreasing when the height levels of tree increasing. This is because the development of thicker secondary wall by cellulose and hemicellulose at the top portion of tree. In comparison, as pointed by Kollmann [10] the bottom portion of tree consists of matured cells. The statistic analysis (Table 2) had further revealed that, clone and height level of tree are highly significant with $r = 2123.62^{**}$ and $r = 838.69^{**}$ (Figure 7).

Conclusion

From this study, the chemical compositions contain in the *Hevea brasiliensis* was determined. The RRIM2024 was found to have a greater chemical composition except for the percentage of ash and lignin. Eventhough both clones were not significantly different towards the solubility of alcohol-toluene. Based on the different height portion of tree, both clones gave the higher value at the bottom portion except for the lignin content. Overall, there are significant different for chemical analysis except for solubility in hot-water. This study hopefully may support in the re-plantation of *Hevea brasiliensis* which give better income to planters due to high yield timber and latex. Besides, the clones also can be used as alternative resources in supporting the furniture manufacturing. Moreover, this research can be used as guidance for further research.

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