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PHYSICAL AND CHEMICAL PROPERTIES OF KELEMPAYAN *(Neolamarckia cadamba sp.)*WOOD

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Abstract--The physical and chemical properties are important factors that influence the workability of a material. The main objective of the study is to determine the physical andchemical properties of Kelempayan (Neolamarckia cadamba) with diameter at breastheight ranging between 35cm to 41cm. three Kelempayan trees were cut into three height portion (bottom, middle and top). Samples for physical properties were taken from each height portion and along the radial direction of the stem (near pith, middle and near bark). Samples for chemical determination were taken from the bottom, middle and top portion of the trees. The highest specific gravity of Kelempayan was found at the bottomportion, followed by middle and top portion. Along the radial direction, it was showed that the specific gravity was highest at the near bark, followed by middle and near pith. Percentage of moisture content increased from bottom to top portion. Tree portion was not affected the cold water and hot water solubles, alkali solubility, alcohol toluene solubles, ash content and lignin content.

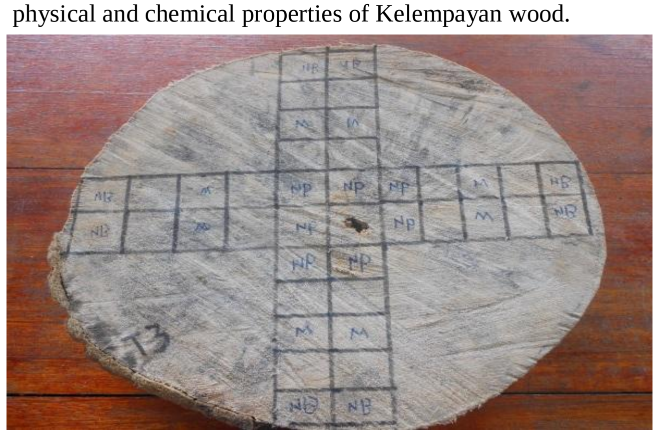
Keywords: Kelempayan, *Neolamarckia cadamba*, physical properties, chemical properties, tree portion, distance.

I. INTRODUCTION

Neolamarckia cadamba is locally known as Kelempayan comes under the family of *Rubiaceae*. It is a fast-growing species with a tall and straight bole. The timber is soft and light with creamy yellowcolour of wood and classified under Light Hardwood in Malaysia. The wood is regarded as non-durable and susceptible to wood rotting fungi and blue stain[1]. However, the timber is widely use as mouldings, general utility furniture, veneer and plywood. As it is a fast-growing species, it could become an alternative raw material to support the wood industries. The tree has potential to be utilized for sawn timber, veneer, chips, pulp and composites [2]. This species are distributed in lowlands to mountain forest to about 1000m altitude, frequently by streams and rivers and in open sites in the forest [3].

The amount of water in wood influences the properties of wood affecting its strength, shrinkage, density and the ability to resist fungi and insect attack. Basically, the strength properties of timber depend very much on the amount of moisture According to Panshin and Zeeuw (1980) [4], the principal constituents of wood are cellulose, hemicellulose, lignin and minor substances called extractives. Cellulose is the major chemical components of woody cell wall and contributing 40-50% of the wood’s dry weight. Unlike cellulose, hemicelluloses are much lower in molecular weight compare with cellulose. They are intimately associated with cellulose and appear to contribute as a structural component in the plant. Lignin comprises 15 to 35% of polymeric substances and often called the cementing agent which binds individual cells together. Extractives are a variety of organic compounds including fats, waxes, alkaloids, simple and complex phenolics, gums, resins, starches terpenes and essential oils. The amount of extractives in wood varies from less than 3 to over 30 percent of the wood oven dry weight (Bowyer et al., 2007)[5]. These components do not contribute to the cell wall structure. The extracts of wood in living plants provide as food reserve (fat, fatty acids, sugar and starch), protectants (terpenes, resin acids and phenols) and plant hormones (phytosterols) Chow et al (2008)[6]. The extractives of wood contribute to wood properties such as color, odor and decay resistance.

The information on Kelempayan is very limited and no solid data on basic properties of Kelempayan have been reported yet. Furthermore, basic knowledge of its physical and chemical composition is crucial in order to use Kelempayan effectively as a raw material especially in wood composite. The main objective of this study is to determine the basic physical and chemical properties of Kelempayan wood.



II. MATERIALS AND METHODS

Three Kelempayan trees with diameters at breast height (DBH) ranging between 35cm to 41cmwere harvested from the Uitm Pahang Forest Reserve and divided into three equal portions namely bottom, middle and top. Two pieces of disc were taken from each portion of fresh Kelempayan. Then, each of the discs were marked and cut into small

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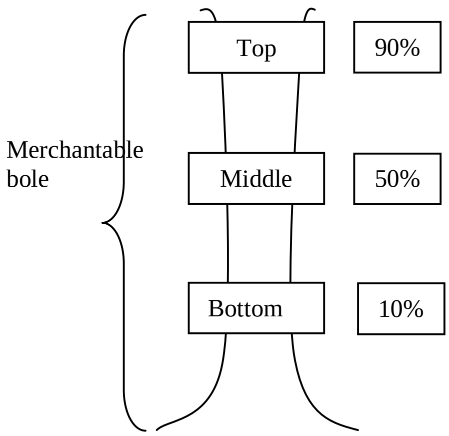
sampleaccording to the distance across the disc which is nearpith (NP), middle (M) and near bark (NB).the method used for the determination of moisture content and specific gravity was based on BS 373:1957 Methods of Testing Small Clear Specimen of Timber [7]. Wood samples for chemical analysis were grounded to pass a 40 mesh sieve and were retained on a 60 mesh sieve. The samples were then air dried for at least one day before chemical analysis so that the reaction of the wood with the reagents used in the chemical analysis is complete. The chemical analysis were carried out according to the following standard procedures; cold water and hot water (T 207 os-75, T 202 os-75), 1% natrium hydroxide soluble (T 207 os-75), alcohol toluene soluble (T 222 os-75), ash content (T 15 os-58), lignin content (T 222 os-75) [8] and holocellulose content [9], respectively.



III. RESULTS AND DISCUSSIONS

Physical Properties

The moisture content and specific gravity are among the main factors that affect usability of wood as a raw material. Moisture makes up part of the weight of each product in use. Therefore, the specific gravity must reflect this fact.

Table 1: Average of Moisture Content and Specific Gravity

Portion	Distance	Moisture Content (%)	Specific Gravity
Bottom	Near Pith	107.3	0.34
	Middle	97.03	0.38
	Near Bark	89.23	0.4
Average		**97.85**	**0.37**
Middle	Near Pith	110.69	0.34
	Middle	101.69	0.38
	Near Bark	91.94	0.41
Average		**101.87**	**0.38**
Top	Near Pith	112.03	0.34
	Middle	100.86	0.37
	Near Bark	92.88	0.4
Average		**100.44**	**0.37**

a) Moisture content

The initial moisture content of Kelempayan according to tree portion and distance are given in Table 1. Highest moisture content was observed in the middle portion (101.87%) while, the lowest was at the bottom portion of wood (97.85%). In Table 2, height portion was observed not significantly affects the moisture content of Kelempayan at $p < 0.05$. In the correlation analysis (Table 4), the moisture content was increase with the increasing of tree portion.

The moisture content increase with tree portion due to the more percentage of sapwood in the top compared to bottom portion. Sapwood has lots of active cell compared to heartwood which compose of more domain cell. According to Bendtsen (1978)[10], top portion of the tree is classified as fastest growth rate, lower density and higher cellulose content.

Table 2: Summary of ANOVA on Physical Properties

SOV	Moisture Content	Specific Gravity
Portion	1.46ns	0.11ns
Distance	27.19**	13.52**
Portion x Distance	0.13ns	0.10ns

Notes: ns = not significant at $p < 0.05$,* significant at $p < 0.05$, **highly significant at $p < 0.01$

Table 3: Summary of DMRT on the Effect of Tree portion on Moisture Content and Specific Gravity

Portion	Moisture Content	Specific Gravity
Bottom	98.15a	0.37a
Middle	101.87a	0.38a
Top	100.12a	0.37a

Distance	Moisture Content	Specific Gravity
Near Pith	109.23a	0.34c
Middle	99.44b	0.38b
Near Bark	91.35c	0.40a

Note: Means with the same letter down the column are not significantly different at $p < 0.05$

Table 4: Correlation Coefficients of Moisture Content and Specific Gravity with Tree Portion and Distance

Properties	Portion	Distance
Moisture Content	0.075	-0.643**
Specific Gravity	-0.012	0.515**

Note: * Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level (2-tailed)

Table 5: Chemical properties of Neolamarckia cadamba according to tree portion

Portion	CW (%)	HW (%)	NaOH (%)	AT (%)	Ash (%)	Lignin (%)	Holo (%)
Top	5.54	6.94	18.33	2.58	0.55	30.92	84.85
Middle	5.75	6.03	17.50	2.24	0.57	24.58	82.11
Bottom	5.65	6.70	18.83	2.54	0.74	30.20	84.65
Average	**5.65**	**6.56**	**18.22**	**2.45**	**0.62**	**28.57**	**83.87**

Note: Values are averages of three determinations
CW = Cold Water Solubles, HW = Hot Water Solubles,
NaOH = Alkali Solubles, AT = Alcohol Toluene Solubles,
Holo = Holocellulose Cold and Hot Water Solubles

b) Specific Gravity

Table 1 gives the average values of specific gravity according to tree portion and distance. The results indicate that the mean specific gravity was ranging between 0.34 to 0.4 and was not significantly affects by the tree portion. However specific gravity was increased significantly from near pith to near bark. This is due to the formation of heartwood which generally somewhat heavier than sapwood due caused by the accumulation of air in the closed cell system. Thus leading to formation of extraneous substances and causing the death of the parenchyma cells (Panshin and Zeeuw, 1980) [4].

The correlation analysis (Table 4) further revealed that the specific gravity showed a negative correlation with increased of tree portion (r = -0.012). Meanwhile, the distance showed positive correlation with the specific gravity (r= 0.015**).Results of the study on specific gravity were compared to the Malaysian timber classification. MTIB (2000) [11] reported that Malaysian timbers are classified into four categories of wood; heavy Hardwood, Medium Hardwood, Light Hardwood, and Softwood. Specific gravity of Kelempayan can be classified as Light Hardwood.

Chemical Properties

The experiments on chemical analysis of wood are designed to obtain the information on chemical composition of wood structure. The chemical components of wood contribute to fiber properties, which ultimately impact product properties and suitability for their uses.

Cold and Hot Water Solubles

Jamaludin (2006) [12] stated that cold and hot water solubles are important in the evaluation of water soluble extracts such as tannin, starch, sugar, pectin and phenolic compounds within any lignocellulosic material. Table 5 displays test results of the cold water (HW) and hot water (HW) solubles of *Neolamarckia cadamba* according to tree portion. The highest average value for CW soluble was observed in the middle portion (5.75%) and the lowest in the top portion (5.54%) of the tree. The highest average value for HW was found in the top portion of the tree (6.94%). The middle portion of the tree resulted in the lowest HW soluble having average value of 6.03%. Table 6 shows the effect of tree portion on the cold water and hot water solubles. Tree portion was found not to affect the cold water soluble but significantly affected the hot water soluble. Table 7 further reveals that cold water solubles had insignificant positive correlation with tree portion (r = 1.00) but hot water solubles is insignificant negative correlation with tree portion (r = -0.10). In general, the portion with lower cold and hot water soluble contained higher lignin content while the portions with high values of cold and hot water soluble contained more active cells.

Alkali Solubles

Lewin and Goldstein, (1991) [13] stated that preparations by extraction with aqueous alkaline solution resulted in isolation of hemicelluloses from wood or from holocellulose. Hot alkali solution extracts low molecular weight carbohydrates consisting mainly hemicellulose and degrades cellulose in wood. The alkali solubles of *Neolamarckia cadamba* (Table 5) ranged from 17.50% to 18.83%. The highest and lowest alkali solubles were observed at the bottom portion (18.83%) and middle portion (17.50%) of the tree. The results further indicated that the alkali soluble tended to have higher values in the bottom portion of tree height.

Table 6 shows the effects of tree portion on alkali soluble of kelempayan wood. Alkali soluble was showed significant effect between bottom and both middle and top portion of the tree. This kind of result was also reported by Wan Mohd Nazri (2009)[14]. The correlation analysis (Table 7) further revealed that the alkali solubility showed insignificant negative correlation with tree portion (r = -0.26). Jamaludin (2006) [12] pointed out that the high alkali solubles related with the high degradation of cellulose and low polyphenol content. In pulping process, this property will give benefits with its high holocellulose content however results in lower yield.

Table 6: Effects of Tree Portion on Chemical Properties

Portion	CW	HW	NaOH	AT	Ash	Lignin	Holo
Top	5.54a	6.94a	18.33b	2.58a	0.55a	30.92a	84.84a
Middle	5.75a	6.03b	17.50c	2.24b	0.57a	24.58b	82.11b
Bottom	5.65a	6.70ab	18.83a	2.54a	0.74a	30.20a	84.65a

Note: Different letters down the column indicate significant at $p<0.05$

CW = Cold Water Solubles, HW = Hot Water Solubles, NaOH = Alkali Solubles, AT = Alcohol Toluene Solubles, Holo = Holocellulose

Table 7: Correlation Coefficients of Chemical Properties with Tree Portion

Properties	Portion
Cold water solubles	1.00ns
Hot water solubles	-0.10ns
Alkali soluble	-0.26ns
Alcohol toluene solubles	-0.02ns
Ash content	-0.09ns
Lignin content	-0.46ns
Holocellulose content	-0.39ns

Note: ns= not significant at p>0.05

Alcohol Toluene Solubles

Table 5 shows the alcohol toluene soluble content of *Neolamarckia cadamba* ranged from 2.24 to 2.58%. The highest alcohol toluene content was found in the top portion (2.58%) while the lowest was recorded from the middle portion (2.24%). The Duncan's Multiple Range Test (DMRT) (Table 6) indicated that alcohol toluene soluble was significantly affected by tree portion. The correlation analysis further revealed that the alcohol toluene content showed insignificant negative correlation (r = -0.02) with tree portion.

Ash Content

Table 5 indicated that the ash content tended to have higher percentage value in bottom portion of the tree. As expected, the trend for tree portion decreases from bottom to top portion. The ash content of Kelempayan wood sample afforded an average ash content of 0.55 to 0.74%. The highest ash content was observed in the bottom portion (0.74%) while the lowest value in the top portion (0.55%). The ash content shown in the Duncan's Multiple Range Test (DMRT) analysis (Table 6) was insignificant. The correlation analysis (Table 7) further revealed that the ash content insignificantly correlated with tree portion (r = -0.09).

The result indicates that the portion of wood with higher density contributed to the increase in percentage of ash content. This is due to the transformation of sapwood into heartwood from bottom to top portion of the tree. Bottom portion has more heartwood and higher density, thus higher ash content compared with top portion of the tree. According to Panshin and Zeeuw (1980) [4], the transition of sapwood into heartwood is accompanied by the formation of various organic substances, known as extraneous materials or infiltrations, and in hardwoods frequently also by the formation of tyloses in the vessels. Heartwood extractives may increase slightly weight of wood and increasing stability in changing moisture conditions (Miller, 1999) [15].

Lignin Content

Lignin is highly amorphous phenolic polymer of indeterminate molecular weight and it is responsible for providing stiffness to the cell wall. It also serves to bond individual cells together in the middle lamella region. The lignin content of *Neolamarckia cadamba* irrespective of tree portion (Table 5) varied from 24.58 to 30.92%. The highest value was observed at the top portion (30.92%) while the lowest value in the middle portion (24.58%) of the tree. The result observed in Table 6 indicated that lignin content significantly affected by tree portion. The correlation analysis (Table 7) further revealed that the lignin content decreased insignificantly with tree portion (r = -0.46). Hon (1996) [16] in his study found that lignin was first confirmed when wood was treated with concentrated acid. The residue white fibrous materials turned out by this treatment were cellulose and lignin was found to have higher carbon content than cellulose as well as for the stiffness of wood.

Holocellulose Content

The holocellulose content as shown in Table 5 ranged from 82.11 to 84.84%. The highest holocellulose content was found in the top portion (84.84%) while the lowest was recorded from the middle portion (82.11%) of the tree. The Duncan's Multiple Range Test (Table 6) indicated that holocellulose content differed significantly with tree portion. The correlation analysis further revealed that the holocellulose content insignificantly correlated with tree portion (r = -0.39). This implies for the holocellulose content which remains almost constant with increasing tree portion.

IV. CONCLUSION

For the physical properties, the height portion was observed not significantly affects the moisture content and specific gravity of Kelempayan wood but highly significant affected by the distance from near pith to the near bark.The chemical composition of Kelempayan wood was analysed for cold and hot water solubles, alkali solubles, alcohol toluene solubles, ash content, lignin content and holcellulose content. As conclusion, tree portion was found not to affect the chemical components of Kelempayan wood.

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