International Journal of Engineering & Technology, 7 (4.18) (2018) 252-255

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Physical and Chemical Properties of 4 Years Petai Belalang (*Leuca`ena leucocephala*) 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 and chemical properties of Petai Belalang (*Leucaena leucocephala*) with diameter at breast height ranging between 35cm to 41cm. Petai Belalang trees were cut into three height portions (bottom, middle and top). Samples for physical properties were taken from each height portion. Samples for chemical determination came from the bottom, middle and top portion of the trees. The highest specific gravity of Petai Belalang was found at the bottom portion, followed by middle and top portion. Percentage of moisture content increased from bottom to top portion. Tree portion affected the cold water and hot water soluble, alkali solubility, alcohol toluene soluble, ash content and lignin content.

Keywords: *Petai Belalang, Leucaena leucocephala, physical properties, chemical properties, tree portion*

1. Introduction

Petai Belalang known as *Leucaena leucocephala* is a fast growing species and is a leguminous shrub that originates from Central America [21]. It is usually use in Agroforestry systems [15]. *L. leucocephala* is a small plant, non-climbing species with 5 - 10 m height and diameter of trunk being 5 - 50 cm [7]. The bark of young branches is mid grey-brown with shallow orange vertical fissures [13]. According to Hughes [6] the matured branches are rougher, dark grey-brown with a deep red inner bark. It density is about 800 kg/m^3 and in the class of medium to heavy hardwood. *Leucaena* is a New World genus of 22 species in the legume family (*Fabaceae*), subfamily *Mimosoideae* [5].

The accepted taxonomy of the genus is based on the monograph, building on an earlier revision of the Mexican species [24]. This species was long knowns by the name *L. glauca* until intensive nomenclatural detective work showed the correct name to be *L. leucocephala* [4]. Two subspecies that correspond to the well-known agronomic 'varieties' are subsp. *leucocephala* - 'Common' or 'Hawaiian' shrubby varieties, and subp. *glabrata* - 'Giant' or 'Salvador' arborescent varieties [23]. Early (pre-1960) literature refers to the shrubby subsp. *leucocephala*, while more recently in agronomic and forestry interest has focused overwhelmingly on the arborescent subsp. *glabrata*.

The information about Petai belalang on basic physical and chemical properties are not widely published, thus the experiment was carried out. The main objective of this study is to determine the basic physical and chemical properties of 4 year Petai belalang wood.

2. Material and Methods

The air dried *L. leucocephala* sample from bottom, middle and top part were extracted from their cross, radial and tangential planes in form of 2 cm x 2 cm x 2 cm dimension cube. Residue disk portion was taken for chemical properties and particles analysis. Triplicate samples, clear from any defects, were taken from each plane. Wood samples for chemical analysis were grounded to pass a 40 mesh sieve and were retained on a 60 mesh sieve. The samples were 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 was carried out according to the 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) and holocellulose content.

3. Result and Discussion

Specific gravity and moisture content are the main factors in physical properties of wood that affect the usability as a raw material for production.

3.1. Physical Properties of Wood

The result of the average specific gravity and moisture content are summarized in Table 1. The table gave an average of specific gravity of 0.64. The result clearly shows higher result in specific gravity is 0.76 on the bottom of tree portion. There was increasing trend moving from the top to the bottom portion of the tree. At the top portion of the tree the result show 0.56 and the middle portion of tree is 0.60. *L. leucocephala* based on specific gravity can classified as medium hardwood. This followed the Malaysian Timber

Industry Board [11] analysis where Malaysian timber is classified into four categories that is; Softwood, Light Hardwood, Medium Hardwood and Heavy Hardwoods.

Moisture content of wood increased moving from the bottom to the top portion of the tree. At bottom of the tree portion, the result is 50.27% and more moisture content is on the top portion of the tree (62.05%). According to [16], higher moisture resulted from more sapwood percentage at the top of the tree compared to the bottom. More active cell resides at sapwood while more domain cell is in heartwood of the tree [1].

Table 1: Specific Gravity and Moisture Content

Tree Portion	Specific Gravity	Moisture Content (%)
Top	0.56	62.05
Middle	0.60	50.93
Bottom	0.76	50.27
Average	**0.64**	**54.41**

Note: * values are average of 16 samples

The analysis of variance (ANOVA) of the tree portion on interaction between specific gravity and moisture content is shown in Table 2. The tree portion is shown to be significantly affected by both specific gravity and moisture content.

Table 2: The Analysis of Variance (ANOVA) on Physical Properties

SOV	Df	Specific Gravity	Moisture Content
Tree Portion	2	39.56*	5995.36*

Note: SOV = Source of Variance, Df = Degree of Freedom, ns = not significant, * = significant at $p < 0.05$

The summary of Duncan's Multiple Range Test (DMRT) on the effect of tree portion on specific gravity and moisture content can be seen in Fig. 1. The study observed that specific gravity is decreasing moving from the bottom to top height of the tree. Sapwood content and active cell more at top portion of the tree may cause the higher moisture content in tree. Cell wall thickness strongly correlates with wood densities at all height [17]. For moisture content, the reverse occurred, where significant increasing trend from bottom to top of the portion is seen.

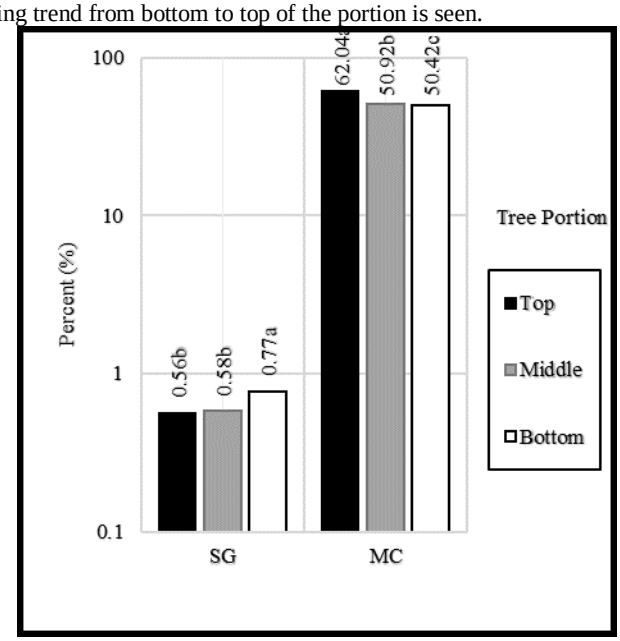

Fig. 1: Summary DMRT on the Effect of Tree Portion on Specific Gravity and Moisture Content

3.2. Chemical Properties of Wood

Chemical analysis consists of determination of general composition content in wood which influences its use and processing control. Wood contains various types of organic and inorganic extraneous materials. Extractive such as tannins, essential oils, resins, waxes, gum starch are simple metabolic intermediates [22]. The extraneous or extractive from the tree can contribute to wood properties such as odour, taste, decay resistance and hygroscopicity. These components could be removed by extraction with solvent such as water, alcohol, acetone, benzene or others [12]. The samples measured in Table 3 are the average percentage of chemical properties according to tree portions.

Table 3: Chemical Properties of *Leucaena Leucocephala* According to Tree Portion

Tree Portion	CW (%)	HW (%)	NaOH (%)	AT (%)	Ash (%)	Lignin (%)	Holo (%)
Top	4.91	6.15	14.20	2.98	0.77	23.35	78.77
Middle	4.02	4.58	13.90	2.90	0.86	23.12	80.50
Bottom	3.77	4.11	13.51	2.87	1.00	22.14	78.33

Note: Values are averages of three determinations, CW = Cold Water Solubles, HW = Hot Water Solubles, NaOH = 1% NaOH Solubles, AT = Alcohol Toluene Solubles, Holo = Holocellulose

The ANOVA of effect of tree portion in Table 4 shows significance effect of hot water soluble, ash content, lignin content and holocellulose content. Meanwhile, cold water, alcohol toluene and 1% NaOH solution shows no significant difference.

Table 4: The Analysis of Variance (ANOVA) on Chemical Properties

SOV	Df	CW	HW	AC	NaOH	AT	LC	Holo
Tree Portion	2	4.16ns	80.37*	29.14*	3.53ns	2.123ns	25.05*	6.08*

Note: SOV = Source of Variance, Df = Degree of Freedom, ns = not significant, * = significant at $p < 0.05$, CW = Cold Water Solubles, HW = Hot Water Solubles, NaOH = 1% NaOH Solubles, AT = Alcohol Toluene Solubles, Holo = Holocellulose

Table 5 on the effect of tree portion on chemical properties indicated that alcohol toluene extract was significantly higher at the top portion compared to the middle and bottom portion. Cold water soluble was significantly lower at the bottom portion compared to the middle and bottom portion. For 1% NaOH no significant difference between the three portions was seen. Ash content was observed higher at the bottom portion than the middle and top portion of tree. Hot water soluble also indicated higher value at the top portion than the middle and bottom portion of tree. Meanwhile, on lignin content soluble shows that there are no significant different between top and middle portion of the tree. Holocellulose shows significantly higher value at middle portion of the tree.

Table 5: Summary of DMRT on the Effect of Tree Portion on Chemical Properties

Tree Portion	CW	HW	AC	NaOH	AT	LC	Holo
Top	4.91a	6.15a	0.77c	14.13a	2.98a	23.30a	78.77b
Middle	4.02ab	4.58b	0.86b	13.81ab	2.90a	23.30a	80.50a
Bottom	3.77b	4.11c	1.00a	13.47b	2.86a	32.10b	78.33b

Note: Means with the same letter the column is not significantly different at $p > 0.05$, CW = Cold Water Soluble, HW = Hot Water Soluble, NaOH = 1% NaOH Soluble, AT = Alcohol Toluene Soluble, Holo = Holocellulose

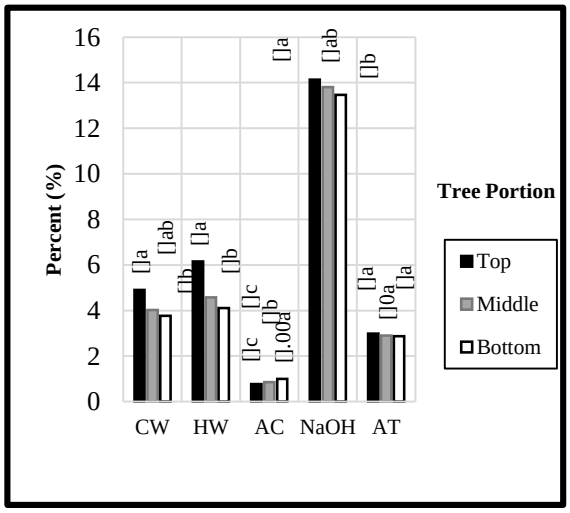

Fig. 2: Summary DMRT on CW, HW, AC, NaOH and AT

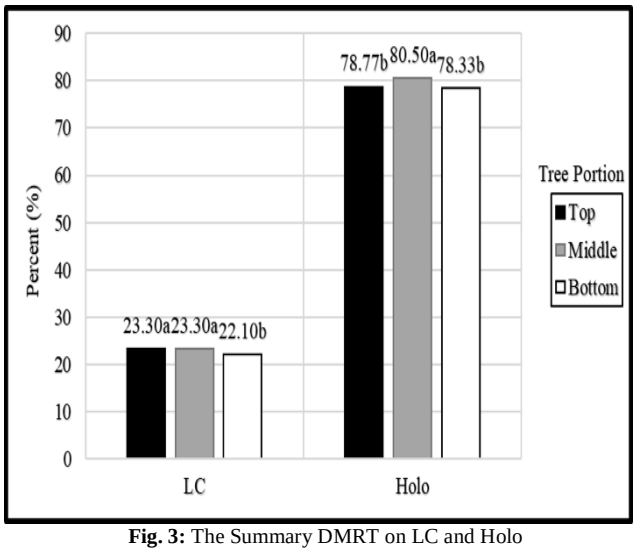

Fig. 3: The Summary DMRT on LC and Holo

The extractions with hot and cold condition are important to evaluate water soluble extract in wood. The extraction from water soluble can detect presence of tannin, phenolics, starch, sugar and colouring [8]. Table 4 shows the average value of cold and hot water soluble according to tree portion. Cold and hot water soluble is similarly higher on top portion of tree. Cold water soluble shows top portion is 4.91% greater than middle portion is 4.02% and the lowest is on bottom portion of the tree. On hot water shows that top portion is 6.15%. This is probably related to the higher active cells content on top portion of tree. More active cells content gave high values result on cold and hot water soluble [22]. The highest ash content was found at the bottom portion (1.00%) of the tree while the lowest at the top portion (0.77%) of the tree. Ash content decreases from the bottom to the top portion of the tree. The effect of tree portion shows significant different between bottom, middle and top. The ash content as silica could be the reason for more ash presence at the bottom portion of tree [9]. The increasing of stability and weight of wood due to changes of the moisture content may be caused by heartwood extractive [14].
Wood decay and damage caused by plant pest and animals can be related to the process in 1% NaOH soluble [3]. The 1% NaOH solubles shows no significant difference for top, middle and bottom portion of the tree. Despite the insignificant difference, the top portion of tree shows the higher result (14.13%) better than middle (13.81%). The lowest result at bottom portion of tree (13.47%). 1% NaOH soluble are higher in juvenile and youngest portion as high alkali solubility degree help to defend against bacterial attack [20].

Alcohol toluene soluble shows no significant different between top, middle and bottom portion of tree. The top portion showed a higher percentage, better than the middle and bottom portion of the tree. Top portion is 2.98% and middle and bottom portion shows slightly different value of result 2.90% and 2.87% respectively. Important factor in fungal resistance are recognized in extractive compound as on heartwood or young shoots [18]. Thus, the top portion alcohol-toluene level is a defence mechanism for the tree. Fig. 3 shows the graph of summary DMRT on the LC and Holo.

Cementing agent known as lignin binds the individual cells together [14]. There was no significant different between top and middle portion of the tree. The highest percentage value shares same result for top and middle (23.09%). The lowest percentage was shown at bottom portion (22.10%). The behaviour of the lignin is increasing moving from top to bottom of the tree [2]. Most of the lignin is found inside the cell wall as an intra-cellular lignin, another less found is in the middle lamella as extracellular lignin [19]. Lignin as binding agent gave more strength in mechanical properties of board. For Petai Belalang, this amount is different from rubberwood where lignin content of rubberwood is more on top portion of the tree [10].

For the hollocellulose content highest value was observed at middle portion (80.50%) while the lowest value in the bottom portion (78.33%). Top portion of tree shows the highest (78.77%) better than bottom portion of the tree. Top and bottom portion of the tree are not significantly different. Generally, the lower the density of tree, the higher the rate of cellulose content [1].

4. Conclusion

The study revealed that physical properties, SG and MC, are affected by tree portion significantly. The chemical properties of *L. leucocephala* wood analysed indicated significant effect for hot water soluble, ash content, alcohol toluene soluble, lignin content and holocellulose content within portions. However, cold water and 1% NaOH solution shows no significant difference. The make-up of lignin opposed that of the rubberwood and holocellulose at above 78% gave indication of potential of raw material for board making.

Acknowledgement

We sincerely express thank and gratitude to all members that helped in completion of this work.

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