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Wood proximate and physical propertyanalysis of Lubeg (*Syzygium lineatum* DC.) Merr. & L. M. Perry) tree species in Apayao

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Key words: *Syzygium lineatum*, Wood proximate, Physical property, Tree species, Apayao

Abstract

The equilibrated ground samples of the wood butt, mid and top portions of the three (3) Lubeg tree species collected in the province of Apayao were analyzed for percent moisture content, percent ash content, percent lignin, percent ethanol cyclohexane, percent holo-cellulose and percent alpha-cellulose content. It was found out that the percent moisture content; percent ash content, percent lignin, percent ethanol cyclohexane and percent alpha-cellulose content are highly significant at 1% level while percent holo-cellulose content of the Lubeg tree was found out to be not significant. These reported findings of the study suggested considerable specific end-uses for Lubeg trees species such as biofuel and as raw material for pulp and paper manufacture. Result of the study conducted, the moisture content and relative density of Lubeg tree at different levels are not significant, and this means that whatever part of Lubeg tree the moisture content and the relative density are the same. Result of the study revealed that the relative density and percent moisture content of the Lubeg tree falls under moderately high classification which can be substantially utilized for house and building construction such as posts, beams, trusses, studs, door panels, and flooring, veneer and plywood, bobbins, spindles, bowling pins, bridges, and wharf timber piles and other uses requiring hard and strong wood. On the other hand, volumetric shrinkage of the wood of Lubeg tree falls under moderately low volumetric shrinkage which denotes that the wood can be utilized for high to common-grade furniture manufacture and other uses such as house framing, flooring and ceiling. Also acceptable for millworks/joinery, woodcrafts, novelties, picker sticks and also for musical instruments.

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Introduction

Wood resources continue to play an important role in the world, from packaging materials to buildings and to transportation structures. Wood has been useful to human societies for thousands of years; archeological discoveries have shown that wood was used by ancient civilizations as a construction material, as a substrate for ornate decorative objects, and for providing the final resting place for royalty. Wood and wood products supplies for industrial, construction and others including research purposes. It is the single most important raw material in pulp and paper production, therefore has to play a major role in industrial and economic growth of nation (Riki, *et al.,* 2019).

Wood quality is defined as the specific combination of its properties that are most suitable for specific final product and depends on physical, chemical composition, anatomical and mechanical features of wood (Zobel, 1989).

The chemical composition of wood is a key factor in the properties and uses of wood. The contents of the major chemical components significantly affect the physical and mechanical properties of lignocellulosic materials. Chemical composition of wood has been proven to influence several wood properties and therefore the suitability of wood to specific purposes. Generally, lignocellulose materials from wood and non-wood plant consist of cellulose, hemicellulose, lignin, extractives and some inorganic matter. Information on the chemical composition is important in deciding the techno-commercial suitability, pulping method and paper strength of a particular wood material (Abdul-Khalil, *et al.*, 2010). In addition, some parts of trees aside from its wood like leaves, bark and sap are used for the production of herbal medicines, antioxidants, cosmetics, dietary supplements, and drinks (Karnaouri *et al.,* 2016).

The most studied physical properties of wood for determining the wood end uses comprise density, wood-water-relations, shrinkage, swelling and color (Bowyer *et al.,* 2003). Color and lustrous properties of wood is important in identification. Moisture in wood is found as water vapour, free water in the cell lumens and cavities and as bound water within the cell walls (Choong and Achmadi 1991). When free water is removed from the cell cavity of the wood, is known as fiber saturation point and it reached around 30 percent moisture content. The loss of free water, down to the fiber saturation point, has no effect on strength of wood. However, when water begins to be removed, most strength properties increases. Density is an excellent indicator of wood strength; the higher the density, the stronger the wood (Ali, 2011). Physical properties of wood are the quantitative characteristics of wood and its behavior to external influences other than applied forces. Familiarity of physical properties is important because they can significantly influence the performance of wood used in structural applications (Winandy, 1994).

With the worldwide move to intensive forest management to meet wood demand and preserve the environment, the wood supply has been undergoing a significant change in terms of wood quality. Increasing amount of wood come from managed short-rotation forests, and the proportion of this resource will continue to grow (Zhang, S.Y. 2003). In the Philippines alone, the local sources of the country's wood-based industries are now totally dependent on timber plantation. One of the problems faced by our country's wood industry include insufficient sources of certified seeds and quality planting materials and incomplete information of supply and demand of industrial tree plantation.

Lubeg (*Syzygium lineatum* (DC.) Merr. & L. M. Perry). is under Family Myrtaceae, it reaches a height from 4-5 meters upon maturity.cm x 2-5cm The Leaf is attached to the stem oppositely arranged, alternate, and simple. Leaves are elliptical to elliptical-lanceolate with an average size of 5-12, The stipules are small and deciduous, frequently with an intra-marginal with numerous and close – set secondary veins fairly distinct below, The margin is usually entire, the base is wide and obtuse, the apex is acuminate and with a 1-1.5cm cuspidate.

The bark is flaky and corky; it has a cracking with scaly grayish brown bark that is rough and fissured. The inner part of the bark is turning reddish brown.

The flower is usually regular, perfect solitary or in panicle spikes, it is multipleor inflorescence with pair of bracts from the base, the colour of the flower is white, calyx is superior or epigenous, it has small rounded regular inferior ovary which envelopes the anther. Fruits are berry with thick and fleshy, spongy pulp rind, oblong to ovoid in shape, it has an average diameter of 13mm. the color of the fruit is green when it is young and turns red to violet as it ripens. The fruit is highly perishable and only lasts for about two (2) weeks when ripe.

The phenology of the species starts from the month of July up to the month of September. Lubeg tree, is just among the rare lesser-known tree species, which is ecologically and economically useful, that is growing in the in the province of Apayao and in the province of Cagayan. With this, knowing the chemical and physical composition of wood is vital for wood selection, wood processing, wood property improvement, wood identification, and other applications (Adjaye, 2012).

The potential of endemic but fast growing lesser known species like Lubeg (*Syzygium lineatum* (DC.) Merr. & L. M. Perry) could be tapped in wood utilization industry by exploring their wood proximate chemical and physical properties.

This study aimed to determine the wood proximate/chemical analysis and physical analysis of Lubeg (*Syzygium lineatum* (DC.) Merr. & L. M. Perry) hence, this study.

Materials and methods

Location and Duration of the Study

Laboratory experiment on Wood Proximate/Chemical and Physical properties were done in the province of Apayao particularly at ASC-Forestry Department Laboratory. This study was done for ten (10) months, from October 2016 to July 2017.

Wood Proximate/Chemical Analysis.

Collection and Preparation of wood sticks

Three (3) tree of Lubeg species of at least 25cm in girth were collected from the study site and was use as sample specimen for chemical property determination, a discs shape wood were obtain from the bottom, middle and top most part of the trunk or bole, the discs were manually chipped into a match stick size, at least three (3) kilos of each samples were obtain and oven dried until becomes brittle and were ground in a Wiley mill and screened in a 40 mesh (0.4mm) the equilibrated ground wood samples were tested following the TAPPI standard procedures.

Moisture Content (T264 om-88)

The sample was weighed in a container, dried in an oven at 105±3°C for 2 hours, allowed to cool in a desiccator and weighed. The heating, cooling and weighing was repeated for hourly periods until weights do not change by more than 0.2mg (constant weight). The loss in weight was expressed as the moisture content.

Ash content (TAPPI 211 om-85)

The sample was weighed in a covered crucible and ignited in a muffle furnace at 900±25°C for 30-60 minutes and then weighed. Normally, this analysis is being done at 575±25°C only. Cooling and weighing was repeated until weight of the ash is constant to ±0.2mg.

Ethanol-cyclohexane solubility (TAPPI T204 om-88)

Ethanol and cyclohexane (1:2) was used as solvent to remove the extractives in the sample. Extraction was carried out for 4-5 hours. Contrary to the use of alcohol and benzene, ethanol and cyclohexane was used as solvents to evaluate the extractives since the use of benzene has been prohibited.

Lignin Content (1977 TAPPI pp.143-144)

About 0.1g of ground sample was used in this test. Sulfuric acid was added to the sample, stirred and placed in a 30±0.5°C water bath. After one hour, the mixture was diluted with distilled water. Second hydrolysis was carried out in an autoclave at 120°C for an hour.

The sample was filtered off in pre-weighed crucibles. Constant weight of the sample was obtained. The residue washed in a furnace to account for the mineral content of the sample. The residue was taken as the weight of lignin.

Holo-cellulose (modified procedure of Erickson)

A two-gram of oven-dried extractive-free sample was weighed and placed into a 250mL flask with a small watch glass cover. The specimen was then treated with 150mL of distilled water, 0.2mL of cold glacial acetic acid, and one gram of $NaClO2$ and placed into a water bath maintained between 70oC -- 80oC. Every hour for five hours 0.22mL of cold glacial acetic acid and one gram of $NaClO2$ was added and the contents of the flask were stirred constantly. At the end of five hours, the flasks were placed in an ice water bath until the temperature of the flasks was reduced to 10oC. The contents of the flask were filtered into a coarse porosity fritted-glass crucible of known weight. The residue was washed free of ClO_2 with 500mL of cold distilled water and the residue changed color from yellow to white. The crucibles were then oven-dried at 103 ± 2oC, then cooled in a desiccator, and weighed until a constant weight was reached.

Alpha-Cellulose content

A 3 gram oven-dried sample of holo-cellulose was placed in a 250mL Erlenmeyer flask with a small watch glass cover. The flasks were placed into water bath that was maintained at 20oC. The sample was then treated with 50mL of 17.5 percent NaOH and thoroughly mixed for one minute. After the specimen was allowed to react with the solution for 29 minutes, 50mL of distilled water was added and mixed well for another minute. The reaction continued for five more minutes. The contents of the flask were filtered by aid of vacuum suction into a fritted-glass crucible of known weight. The residue was washed first with 50mL of 8.3 percent NaOH, then with 40mL of 10 percent acetic acid. The residue was washed free of acid with 1,000mL of hot tap water.

The crucible was oven-dried in an oven at 103±2oC, then cooled in a desiccator, and weighed until a constant weight was reached.

Physical Properties of Lubeg

Collection and Preparation of wood samples

Three (3) trees of at least 25cm in girth were obtained from the study site; three bolts (12 inches long) were taken from each tree. A 152mm (6”) thick disc was cut from the bolts for physical property specimens. The procedure specified at the ASTM Standards for Testing Small Clear Specimens of Timber. ASTM Designation D143-94 (2000) was followed.

Moisture Content and Relative Density

A test was made on 25 x 25mm specimens surfaced on all sides and was shaved smoothly at the ends. Both moisture content and relative density determinations was made on the same block. Each specimen was weighed at green condition and its volume was determined by immersion method (water-displacement method).

All specimens were open-piled and were allowed to air-dry under room conditions and were dried in an oven at 103$\pm$2^{o}c until a constant weight was attained.

Moisture content and relative density were computed as follows:

$$\%M = \frac{Wg - Wo}{100} \text{ x } 100$$

$$RD = \frac{Wo}{Vg \text{ x } Dw}$$

Where,

Wg	=	green weight
Wo	=	oven dry weight
Vg	=	green volume
Dw	=	density of water = 1.0 gm/cc

Shrinkage Characteristics

A Test were conducted on 25 x 25 x 102mm specimens and were marked three points each in radial and tangential side, also at the longitudinal (end) side. Weight and dimensions were determined. Radial, tangential, longitudinal and volumetric shrinkage at green to oven dry condition were computed.

Data Analysis

The methods used in this study were qualitative and quantitative research, and data analysis depends on the component of study as follows:

Proximate Chemical Analysis

The equilibrated ground samples of butt, middle and top portions of the Lubeg tree species were analyzed for percent moisture content , percent ash content, percent ethanol- cyclohexane, percent lignin, percent holo-cellulose and percent alpha-cellulose content and were replicated three (3 times, except for ethanol-cyclohexane extractives which were replicated two times only due to limited samples. The data gathered were analyzed using the simple Complete Randomized Design (CRD) and the Least Significant Difference Test (LSD) was used for mean comparison.

Physical properties of Lubeg

The procedure specified at the ASTM (American Society for Testing and Materials). Standards for Testing Small Clear Specimens of Timber. ASTM Designation D143-94 (2000) was followed, data gathered on percent moisture content (%MC), relative density and percent shrinkage (%) were subjected to Analysis of Variance (ANOVA) for simple Complete Randomized Design (CRD) and Least Significant Difference Test (LSD) for mean comparison.

Result and discussions

Proximate Chemical Analysis of Lubeg Tree Species

Wood is made up of cellulose, hemicellulose and lignin, but their amount varies between species, provenance or origin and other environmental factors that affect the growth of tree.

To determine possible end-use, chemical composition of the woody portion of trees need to be quantitatively identified for their more efficient utilization. Table 1, shows the summary of percent composition of all the chemical properties of Lubeg species.

The equilibrated ground samples of the wood butt, mid and top portions of the three (3) Lubeg tree species collected in the province of Apayao were analyzed for percent moisture content, percent ash content, percent lignin, percent ethanol cyclohexane, percent holo-cellulose and percent alpha-cellulose content.

It was found out the percent moisture content; percent ash content, percent lignin, percent ethanol cyclohexane and percent alpha-cellulose content are highly significant at 1% level while percent holo-cellulose content of the Lubeg tree was found out to be not significant.

Table 1. Summary table for percent composition of the chemical properties of Lubeg species.

Spp	Portion	MC** %	Ash ** %	Lignin** %	Ethanol** Cyclohexane %	Holo-cellulose^{ns} %	Alpha** Cellulose %
		10.74	5.50	21.23	4.59	74.61	54.83
	Butt	10.65	5.50	20.99	4.93	70.60	54.65
Lubeg		10.64	5.53	21.43	4.97	69.25	54.42
	Ave.	10.68^{a}	5.51^{a}	21.22^{b}	4.83^{a}	71.49	54.63^{b}
		10.69	4.32	21.56	1.06	73.10	56.28
	Mid	10.73	4.31	21.53	1.34	76.17	55.84
		10.72	4.30	21.55	1.19	77.23	55.48
	Ave	10.71^{a}	4.31^{b}	21.55^{b}	1.20^{c}	75.5	55.87^{a}
		10.53	3.60	24.82	4.11	72.42	52.40
	Top	10.53	3.57	24.61	4.20	75.00	52.12
		10.52	3.56	25.04	4.28	74.93	52.19
	Ave.	10.53c	3.58^{c}	24.82^{a}	4.2^{b}	74.11	52.24^{c}
CV%		0.31	0.40	0.79	4.46	2.99	0.50

**Highly significant at 1%

^{ns} not significant

Percent Moisture Content

Moisture content of the butt, mid, top portion of the Lubeg tree species ranges from 10.52%- 10.74% (Fig. 1). The result for Moisture content showed highly significant. Those at the middle portion of the Lubeg tree species is significantly higher (10.71%) in terms of moisture over the top portion (10.53%) but not on the butt portion (10.68%). However, the butt and the mid portion are not significantly different from each other.

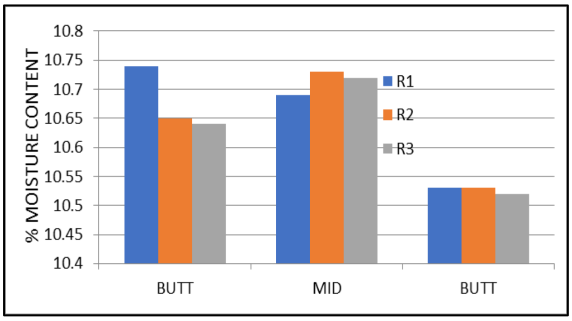

Fig. 1. Patterns of% moisture content from bottom part to the top portion of the Lubeg species.

Ash%

Ash contains inorganic materials and other mineral salts present in wood. It consists mainly of the non-volatile and non-combustible inorganic compounds embedded in the cellulosic matrix (Moran and Habon, 2008, TAPPI, 1994). In the experiment conducted on the wood chemical analysis of Lubeg species obtained in the province of Apayao, analysis of variance revealed highly significant on the% ash content. The ash content ranged from 3.56% to 5.51%, those at the bottom portion are significantly higher (5.51%) in terms of ash over the middle (4.31%) and top portion (3.58%), the findings implies that it is in the bottom part of the Lubeg tree species where the mineral constituents are being stored.

Lignin and Holo-cellulose

Lignin serves as the cementing agent of the wood cells together and to impart rigidity to the cell walls, usually constitutes about one-fourth to one-third of the dry wood substance. Most hardwoods consists 22% to 28% dry weight (Petterson, 1984). Likewise, lignin provides plant tissues and individual fibers with compressive strength and hardens the cell wall of the fibers, to protect the Carbohydrates from chemical and physical damage (Saheb and Jog, 1999).

According to Dionglay *et al.* 2014, in their study on the chemical properties of plantation- grown Earpod, that lower lignin content is more favorable for pulp and paper. Materials having high lignin content require more processing, bleaching and cooking, this findings is congruent with the result of the study conducted regarding the chemical properties of Lubeg tree. The result of the study falls within the range limit of a lignin content for Hardwood as shown in Table 2 which ranges from 20.99% - 24.82% .

Table 2. Result of physical properties of Lubeg (*Syzygium liniatum*).

Type of Test	Sample Mark				Classification
	Butt	Middle	Top	Average	
Moisture Content at Test (%)[1/]	72.99	79.31	74.02	75.44	Moderately High
Relative Density[2/]	0.570	0.530	0.532	0.544	
Shrinkage at Test (%)[2/]					
Tangential	5.81	5.51	5.33	5.55	
Radial	4.86	4.54	4.59	4.66	Moderately Low
Longitudinal	0.16	0.20	0.26	0.21	
Volumetric	10.38	9.80	9.67	9.95	

[1]Determined in Accordance with ASTM D143-94: Standard Method of Testing Small Clear Specimens of Timber.

[2]Based on oven-dry weight and volume of samples at test.

Based from the data gathered and as shown in Fig. 3, it was found out that the top portion has higher lignin content (24.82%) which is significantly different from the lignin content of middle (21.55%) and bottom (21.22%**)** portion respectively which are not significantly different from each other. This implies that the wood of Lubeg tree from its butt to mid portion can be significantly utilized for pulp and paper production as stated by Dionglay *et. al.* (2014), in their study on the chemical plantation of grown ear pod. On the other hand, Holo-cellulose is the polysaccharide in bark (Tamayo and Flavier, 2003), in this study, analysis of variance revealed not significant. Although not significant, the holo-cellulose value ranged from 69.25 to 77.23% which showed high value for holo-cellulose and is considered as potential raw material for pulp and paper manufacture.

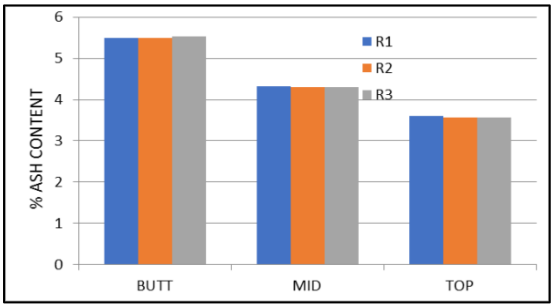

Fig. 2. Patterns for % ash content from bottom to top portion of lubeg tree species.

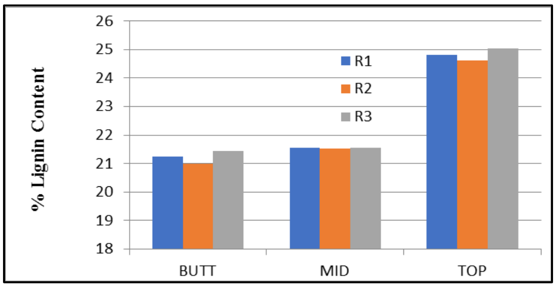

Fig. 3. Patterns for % lignin content from the bottom to the top portion of lubeg tree species.

Ethanol Cyclohexane

Ethanol Cyclohexane is a wood extractive which is one among the extraneous components of wood. It is usually soluble in neutral solvents. They are low molecular organic compounds, fats and resin acids, oils, non-volatile hydrocarbons, and waxes. Some extractives are responsible in the resistance of wood decay or termite attack, other are responsible for the color, odor and gluability of wood. The amount of these extractives also serves as parameters for pulp yield and quality, and also have notable effects on finishing and preservation (Dionglay, 2014). In the study, it was found out that the bottom portion is significantly higher (4.83%) over the top (4.2%) and the middle (1.20%) portion which are significantly different from each other (Fig.5).

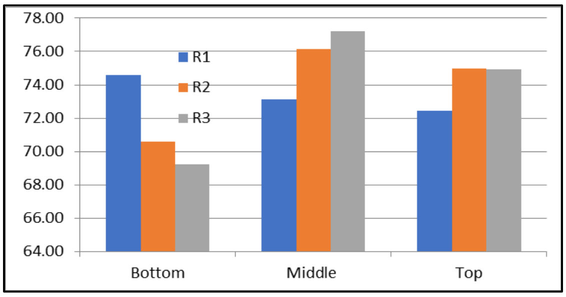

Fig. 4. Patterns for % holocellulose content from the bottom to the top portion of Lubeg tree species.

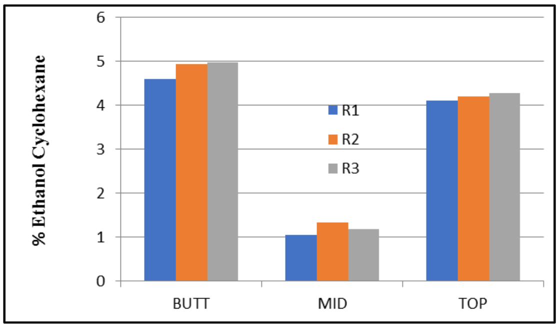

Fig. 5. Patterns for % ethanol cyclohexane content from the bottom to the top portion of lubeg tree species.

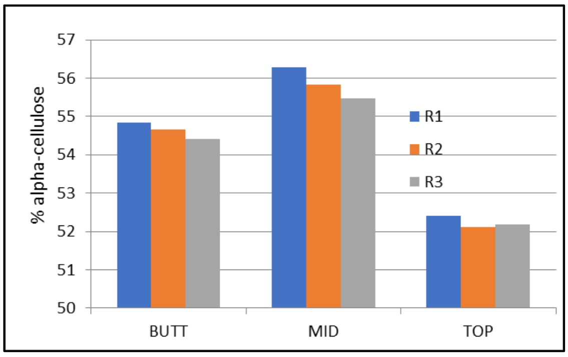

Fig. 6. Patterns for % alpha-cellulose content from the bottom to the top portion of lubeg tree species.

In terms of Ethanol Cyclohexane content of Lubeg tree, it was found out to be high at their butt and top section, which means that this section are resistant to any wood decay.

Alpha- Cellulose

Cellulose is responsible for strength in wood fiber. In the case of paper, its strength depends on cellulose content of raw materials. Analysis of Variance showed highly significant in terms to its Alpha cellulose. Those at the middle portion of the Lubeg tree is significantly higher with a mean Alpha-Cellulose content of 55.87% compared to bottom and top portion with a mean Alpha-cellulose content of 54.63% and 52.24% respectively, on the whole, the Alpha-Cellulose content of Lubeg tree ranges from 52.12% - 56.28%. of the three sections (butt, mid, top) of Lubeg tree tested, it was found out that mid-section has a high value content which is promising for pulp and paper production. Nieschlag *et. al.* (1960) stated in their report in the "Search for New Fiber Crops", that plant material with a 34% and over of Alpha-Cellulose content is characterized as promising for pulp and paper manufacture. Based from the data gathered, it indicates that Lubeg tree has potential for pulp and paper utilization.

Physical Properties of Lubeg Tree Species in Apayao
Comprehensive knowledge of physical properties of a tree species whether it is a timber or fruit bearing tree is very important in promoting their use as potential substitutes for the rapidly depleting commercial timber species. Information on these properties will facilitate the use of wood as structural material, alternate species for specific end-uses, and for possible new application (Alipon & Bondad, 2005).

The important physical properties of timber are Moisture Content (MC), Relative Density (RD) and Volumetric Shrinkage (VS). Lubeg is an indigenous fruit tree species thriving in the province of Apayao which remains unexplored.

The analysis of Variance for relative density and Percent (%) Moisture Content revealed not significant respectively. Fig. 7, shows the patterns of relative density variations along the height levels. It was found out that there is significant value for relative density at the butt section (0.570) and the mid and top section are with almost the same value of 0.530 and 0.532 respectively.

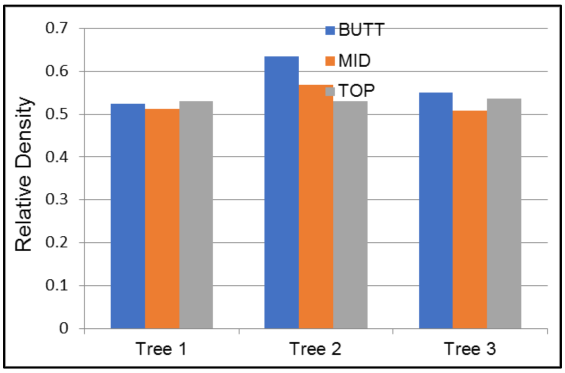

Fig. 7. Patterns of relative density variations along the lubeg tree height levels.

Based from the result of the study, there is a variations of relative density among the three trees and within their height levels. According to Alipon and Bondad (2005), there is a distinct patterns of variations in many features, within a single tree, length of cells, thickness of cell wall, angle at which the cells lie with respect to the vertical axis all show systematic trends outwards from the center tree to the bark and upwards from the base to the top. This pattern results in the formations of a core wood with many undesirable properties.

This zone is known as juvenile wood as opposed to mature wood occurring outside. On the other hand percent moisture content (%MC) for the Lubeg tree tested, found out to be high at the middle portion with value of 79.31%, at the top found to be 74.02% and at the butt portion of 72.99% (Fig. 8).

Result for both relative density (RD) and percent moisture content (%MC) of the Lubeg tree revealed not significant, although not significant but from the result of Standard Method of testing Small Clear Specimens of Timber consists an average value of 0.544 and 75%.44 respectively which falls under moderately high based from the Strength Classification Limits for Grouping Philippine Timber species (FPRDI Journal, 2006).

This means that in terms of the relative density (RD) and percent moisture content (%MC) of the Lubeg tree, it can be substantially utilized for house and building construction such as posts, beams, trusses, studs, door panels, and flooring, also for automobile and truck bodies, veneer and plywood, bobbins, spindles, bowling pins, bridges, and wharf timber piles and other uses requiring hard and strong wood.

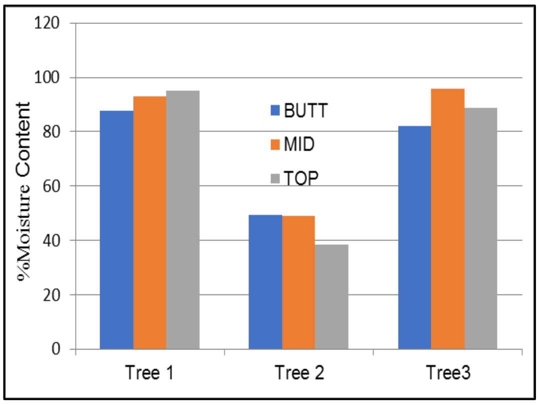

Fig. 8. Patterns of moisture content variations along tree height levels.

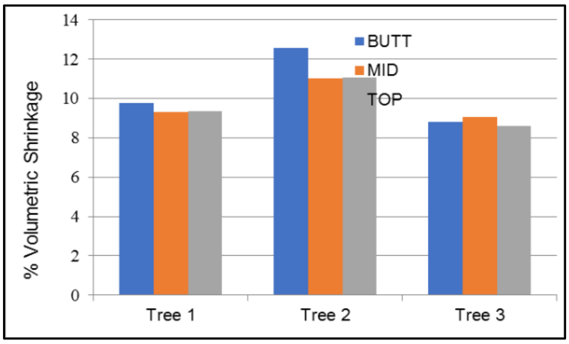

Fig. 9. Patterns of Volumetric Shrinkage Variations Along Tree Height Levels.

For volumetric shrinkage, the result revealed highly significant at 1% level. Those at the butt portion are significantly higher in terms of volumetric shrinkage over the top and mid portion. The post mean analysis also revealed that the bottom portions are not statistically different in terms of volumetric shrinkage compared to those in top and mid-section of the tree. Based from the result obtained during the conduct of laboratory experiment, the volumetric shrinkage of the wood of Lubeg tree falls under Group IV moderately low volumetric shrinkage ranging from 9.6%-10.38% which denotes that the wood can be utilized for high to common-grade furniture manufacture and other uses such as house framing, flooring and ceiling. Also acceptable for millworks/joinery, woodcrafts, novelties, picker sticks and also for musical instruments (FPRDI Journal, 2006).

Conclusion

Generally, the reported findings of the study suggest considerable specific end-uses for Lubeg trees species such as biofuel and as raw material for pulp and paper manufacture. Further, the result of the relative density and percent moisture content of the Lubeg tree falls under moderately high classification which can be substantially utilized for house and building construction such as posts, beams, trusses, studs, door panels, and flooring, veneer and plywood, bobbins, spindles, bowling pins, bridges, and wharf timber piles and other uses requiring hard and strong wood. On the other hand, volumetric shrinkage of the wood of Lubeg tree falls under moderately low volumetric shrinkage which denotes that the wood can be utilized for high to common-grade furniture manufacture and other uses such as house framing, flooring and ceiling. Also acceptable for millworks/ joinery, woodcrafts, novelties, picker sticks and also for musical instruments.

Recommendations

In the light of the significant results of the study, it is recommended that studies on the correlations between the chemical and anatomical properties of Lubeg tree be conducted.

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