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EXTRACTIVES, CELLULOSE, HEMICELLULOSE AND ASH CONTENT VARIATION IN *EUCALYPTUS CAMALDULENSIS* TREES GROWN IN EGYPT.

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ABSTRACT

Variation of extractives, cellulose, hemicellulose and ash contents among and within nine Eucalyptus camaldulensis trees was examined. The variation of the extractives, cellulose and hemicellulose content among the trees was not significant, while the variation of the ash content among the trees was significant. About 30% of total variation of ash was due to tree-to-tree variation.

The study also revealed that magnitude of extractives, cellulose, hemicellulose and ash content was highly significant according to height within tree. Averages at breast height, 25, 50, 75% of the total steam height were 15.10%, 13.21%, 11.25%, and 10.03% for extractives, while for cellulose, they were 44.79%, 44.06%, 43.22% and 41.78%. For hemicellulose, they were 22.73%, 23.92%, 25.57% and 27.75% and for ash, they were 0.46%, 0.50%, 0.55%, 0.64% ,respectively.

The most of variation in chemical contents was due to height variation. It was about 85% of total variation for extractive, about 94% for cellulose, about 96% for hemicellulose and about 61% for ash content.

From the results, it can be concluded that the utilization of wood from the base is recommended than wood from the top for furniture, pulp and charcoal. On the other hand, the wood from the top is recommended to turn the wood to furfural and ethanol.

Key words: *Variation, Extractive, Cellulose, Hemicellulose, Ash content, Eucalyptus camaldulensis trees.*

INTRODUCTION

Wood raw material lacking in Egypt due to the absence of natural forest resources and the growing need for this raw material has increased recently due to the increased in Egypt. Therefore, the plantation in Egypt is directed toward fast growing species especially these adapted to Egyptian environmental conditions (El-Sayed *et al* 2004). One of these fast growing trees is River red gum (*Eucalyptus camaldulensis* Dehn.) which was introduced into Egypt in 1800's. It is highly adapted to local environmental conditions. Some trees planted on the banks of River Nile may reach 150 cm in diameter and over 30 meters in height. The tree is traditionally planted as windbreak to provide shade and as a source for fuel and wood for primitive carpentry. However, some of eucalypt wood is now going into furniture and particleboard industry and charcoal production (El-lakany *et al* 1980). None of the local pulp and paper mills in Egypt use eucalypt wood as they depends mainly on rice straw, bagasse and imported pulp for production of writing and printing paper. It is expected that Eucalypt pulp, when become available in sufficient quantities, will have great impact on this industry (Badran *et al* 1979)

Chemically, wood cell walls are composed of three groups of structural substances cellulose, hemicellulose, and lignin. Cellulose as the framework substance, contributes its high tensile strength to the complex of wood structure. The presence of hemicelluloses in the cell wall has a tremendous influence on certain physical properties of wood. The function of lignin is to provide rigidity and stiffness to cell walls.

In addition to its major chemical components, wood also contains small (but in some cases quite appreciable) quantities of extraneous components. These extractives exert a diversified influence on the characteristics of wood, wood products, and tissues. They are responsible for colour and durability of wood (Hillis 1972) and cause surface inactivation to veneer (Hancock and Swan 1965). Other properties that have been related to extractive include sorption (Wangaard and Grandos 1967), shrinkage (Choong 1969), adhesion and wettability (Chen 1970), specific gravity and compressive strength (Badran and El-Osta 1977 a and b ; El-Osta *et al.* 1980) and bending strength (Arganbright 1971).

It is well documented that the magnitude of these chemical constituents varies within a single tree from the centre of the stem to the bark, from stump to the crown, between early- and latewood and between sapwood and heartwood (Kollmann and Cote 1968; Panshin and de Zeeuw 1970). Furthermore, information on the magnitude and variation of chemical components of windbreak trees is a prerequisite for successful assessment of these properties and efficient conversion of wood into its end products. In addition, low within-tree variation in the chemical components is a desirable feature, indicating a raw material having a high degree of uniformity.

Cellulose and lignin content are important technology properties for pulp and paper industry. Therefore, before suggesting proper utilization of River red gum trees, it is essential to evaluate the basic technological properties of its wood.

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The objective of this study is to define the pattern of variations in extractives, cellulose, hemicellulose and ash content among the trees and within trees at different stem heights of River red gum.

MATERIALS AND METHODS

Nine straight trees of *Eucalyptus camaldulensis* were selected from about thirteen-year-old. These trees were free from any visible defects. Four discs about 1.5 cm in thickness, free from visibly decayed wood or tension wood, were taken from each tree. One of these discs at breast height, 25, 50, and 75% of the total stem height of the tree. In order to prevent dryness, the discs were placed in numbered plastic bags and transported to the laboratory and stored in freezing temperature for further processing.

Extractives content determination

Samples of air-dry wood were chipped and ground to pass through 40-mesh screen and retain on a 60-mesh screen. Using alcohol-benzene, alcohol 95 percent, and water successively were applied. The procedure is based on ASTM standard D1105-56 (1989). Air dried wood meal was extracted in a soxhlet extractor apparatus for four hr. with two volume of benzene to one volume 95% alcohol, followed by four hours extraction with 95% ethanol, and finally extracted with hot-water for three hr. The percentage of extractives was calculated based on the oven-dry weight of wood samples.

Cellulose determination

Cellulose was determined by the treatment of extractive-free wood meal with nitric acid and sodium hydroxide: one gram of extractive-free wood meal was treated with 20 ml of a solution of nitric acid 3% in flask and was boiled for 30min. The solution was filtered in crucible G3. The residue was treated with 25ml of a solution of sodium hydroxide 3% and was boiled for 30min. The residue was filtered, washed with warm water to neutral filtrate, dried and weighed (Nikitin1960).

Hemicelluloses content

Hemicellulose content was determined by the treatment of extractive free wood meal (1-2g) with 50-100 ml sulfuric acid 2% and boiled for 1 hr. under a reflex condenser and filtrated in crucible G2. After that the residue was washed with 500 ml of hot distilled water to free of acid, and contents were dried in an oven at 105 ± 2°C, cooled in a dessicator and weighed (Rozmarin and Simionescu 1973).

Ash content

Ash content of wood was determined according to the NREL Chemical Analysis and Testing Task Laboratory Analytical Procedure #005, (1994). Approximately 1.0g of oven-dry sample was placed into the crucible. The sample in an uncovered crucible was heated gradually, then ignited at 575±25°C for a minimum of three hours, or until all the carbon is eliminated. Ash content was calculated as a percentage of residues based on the oven-dry wood meal weight.

Statistical analysis

The analysis of variance was carried out according to the nested design (Snedecor and Cochran 1967), in order to examine the variability in extractives, cellulose, hemicellulose and ash content between the trees and within trees at different height. The variance components were also determined. Also, the least significant difference method at 95% level of probability ($L.S.D_{0.05}$) was used to test the differences among the means of each parameter. The data exported to a PC-SAS data set for statistical analysis using the GLM procedure.

RESULTS AND DISCUSSIONS

Extractives content

Table (1) showed that, the variation in extractives between trees was not significant but the interaction of height level within trees was highly significant, the variance component of the height level is 5.305, which represents about 85.06 percent of the total variation in extractives. There is decrease in extractives with increasing the tree height level and Averages for extractives were 15.10%, 13.21%, 11.25% and 10.03% at breast height, 25, 50, 75% of the total steam height, respectively Table (2). It concluded from Taylor *et al.* (2003) that, the heart wood extractive chemistry is complex and varies significant within and between trees and tree species. This result is in agreement with conclusion obtained by El-Osta and Abo-hassan (1983). While the Villarreal *et al.* (2006) found that, the percentage of extractive content in eucalypt residues was 1.23%. Also Ye et al. (2005) indicated that, the organic extractive content of juvenile eucalypt was 7.6%.

Cellulose content

The analysis of variance in Table (3) revealed that there is no significant difference in cellulose content values between trees but the interaction of height level within trees was significant at 1.0 percent level of probability, the variance component of the height level is 1.765, which represents about 94.43 percent of the total variation. Table (2) revealed that, cellulose content decrease with increasing the height levels and the average cellulose content was 44.79%, 44.06%, 43.22% and 41.78% at breast height, 25, 50, 75% of the total steam height, respectively. This trend of results has been reported by Senoo (1970) and Uprichard (1971), who found that cellulose content decreased about 2% in softwood along the vertical axis of the tree from base upward. While Rodrigues *et al.* (2001) found differences occur between lignin and higher cellulose in the cross section part with the highest radial growth.

Hemicellulose content

Table (4) showed that, the variation in hemicellulose between trees was not significant but the interaction of height level within trees was highly significant, the variance component of the height level

Table (1) Combined analysis of variance with estimated mean squares (E.M.S) for extractives.

S.O.V	d.f	M.S	F	E.M.S
Tree (T)	8	3.46	$0.33^{N.S}$	$\sigma^2e+2\sigma^2L+8\sigma^2T$
Height (H)/T	27	10.645	308.54**	$\sigma^2e+2\sigma^2L$
Sample (Sp)/H/T	36	0.034		σ^2e
Total	71			

$\sigma^2e = 3.45x10^{-2}$, $\sigma^2H = 5.305$, $\sigma^2T = 0.8968$. Where: σ^2e, σ^2H, σ^2T, are the variance components for error, height/tree, and tree, respectively.

** significant at 0.01 level of confidence.

N.S not significant.

Table (2) Effect of sample height on means of extractive, cellulose, hemicellulose and ash content(%).

Chemical analysis	Sample height				L.S.D (0.05)
	Dbh	25 %	50 %	75 %	
Extractive	15.10	13.21	11.25	10.03	0.37
cellulose	44.79	44.06	43.22	41.78	0.43
hemicellulose	22.73	23.92	25.57	27.75	0.41
ash	0.46	0.50	0.55	0.64	0.018

Table (3) Combined analysis of variance with estimated mean squares (E.M.S) for cellulose content.

S.O.V	d.f	M.S	F	E.M.S
Tree (T)	8	3.10	$0.87^{N.S}$	$\sigma^2e+2\sigma^2L+8\sigma^2T$
Height (H)/T	27	3.57	79.32**	$\sigma^2e+2\sigma^2L$
Sample (Sp)/H/T	36	0.045		σ^2e
Total	71			

$\sigma^2e = 0.045$, $\sigma^2H = 1.765$, $\sigma^2T = 0.059$. Where: σ^2e, σ^2H, σ^2T are the variance components for error, height/tree and tree, respectively.

** significant at 0.01 level of confidence.

N.S not significant.

Table (4) Combined analysis of variance with estimated mean squares (E.M.S) for hemicellulose.

S.O.V	d.f	M.S	F	E.M.S
Tree (T)	8	9.26	$0.88^{N.S}$	$\sigma^2e+2\sigma^2L+8\sigma^2T$
Height (H)/T	27	10.50	252.31**	$\sigma^2e+2\sigma^2L$
Sample (Sp)/H/T	36	0.041		σ^2e
Total	71			

$\sigma^2e = 4.16x10^{-2}$, $\sigma^2H = 5.233$, $\sigma^2T = 0.1558$. Where: σ^2e, σ^2H, σ^2T, are the variance components for error, height/tree, and tree, respectively.

** significant at 0.01 level of confidence.

N.S not significant.

Table (5) Combined analysis of variance with estimated mean squares (E.M.S) for ash.

S.O.V	d.f	M.S	F	E.M.S
Tree (T)	8	0.036	2.94*	$\sigma^2e+2\sigma^2L+8\sigma^2T$
Height (H)/T	27	0.012	149.34**	$\sigma^2e+2\sigma^2L$
Sample (Sp)/H/T	36	0.00008		σ^2e
Total	71			

$\sigma^2e = 8.33x10^{-5}$, $\sigma^2H = 6.18\ x10^{-3}$, $\sigma^2T = 3.02\ x10^{-3}$. Where: σ^2e, σ^2H, σ^2T, are the variance components for error, height/tree, and tree, respectively.

** significant at 0.01 level of confidence.

*significant at 0.05 level of confidence.

is 5.233, which represents about 96.36 percent of the total variation. There is increase in hemicellulose content with increasing the tree height level and the average hemicellulose content was 22.73%, 23.92%, 25.57% and 27.75% at breast height, 25, 50, 75% of the total steam height, respectively Table (2). This trend of results has been reported by Harwood (1971) who found that in *Pinus radiata* the xylose, galactose and arabinose contents increased slightly with height in the tree trunk. While Jones *et al.* (2006) found that, the percentage of hemicellulose content in *Pinus taeda* was 23.11%.

Ash content

Table (5) showed that, the variation in ash content between trees was significant and the variance component of the trees is 0.003, which represents about 30.06 percent of the total variation in ash content. Also, the Table (5) indicated that, the interaction of height level within trees was highly significant and the variance component of the height level is 0.0061, which represents about 61.12 percent of the total variation in ash content. Table (2) indicated that, there is increase in ash content with increasing the tree height level. This result indicated that the base part of the trunk was lower content of ash, so it is recommended to use as wood fuels and charcoal.

The result of the present study on variation in extractives, cellulose, hemicellulose and ash content of *Eucalyptus camaldulensis* between trees and within trees are very important to chemical technologists and wood scientists working on pulp wood quality parameters in hardwoods. The implication of these results is that, we can select the specific height of the tree with high cellulose content from the base if the wood is to be exposed to tensile strength and choosing height levels with high extractives content from the base if resistance to applied tensile strength and durability to fungus attach are required. On the other hand, we can select the specific height of the tree with high hemicellulose content from the top if the wood will be turned to furfural and ethanol production.

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الملخص العربى

تباين نسبة المستخلصات والسليولوز والهيميسليولوز والرماد فى أشجار الكافور (*EUCALYPTUS CAMALDULENSIS*) النامى فى مصر

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تناول هذا البحث دراسة التباين فى نسبة المستخلصات والسليولوز والهيميسليولوز والرماد بين وداخل تسعة أشجار من الكافور *Eucalyptus camaldulensis* Dhin. أوضحت النتائج أن الإختلافات فى نسبة المستخلصات والسليولوز والهيميسليولوز بين الأشجار لم تكن معنوية بينما الإختلافات فى نسبة الرماد بين الأشجار كانت معنوية وأن حوالى ٣٠٪ من الإختلافات فى نسبة الرماد ترجع الى الأشجار الفردية.

كما أوضحت الدراسة أن هناك معنوية عالية فى نسبة المستخلصات والسليولوز والهيميسليولوز والرماد راجعة الى الإرتفاعات المختلفة داخل نفس الشجرة، وكانت المتوسطات عند إرتفاع مستوى الصدر و٢٥٪ و٥٠٪ و٧٥٪ من طول الساق هو ١٥,١٠٪ و١٣,٢١ ٪ و١١,٢٥ ٪ و١٠,٠٣٪ للمستخلصات على التوالى، وكان متوسط نسبة السليولوز للخشب ٤٤,٧٩٪ و٤٤,٠٦ ٪ و٤٣,٢٢٪ و٤١,٧٨٪ على التوالى، وأن نسبة الهيميسليولوز كانت ٢٢,٧٣٪ و٢٣,٩٢ ٪ و٢٥,٥٧ ٪ و٢٧,٧٥٪ على التوالى. بينما متوسط نسبة الرماد للخشب عند إرتفاع مستوى الصدر كانت ٠,٤٦٪ وللخشب عند إرتفاع ٢٥٪ من طول الساق كانت ٠,٥٠٪ وللخشب عند إرتفاع ٥٠٪ كانت ٠,٥٥ ٪ وعند إرتفاع ٧٥٪ كانت ٠,٦٤٪.

كما أوضحت الدراسة أن معظم الإختلافات فى المحتوى الكيميائى للأشجار ترجع الى الإختلاف فى إرتفاع الأشجار وكانت النسبة حوالى ٨٥٪ للمستخلصات و٩٤٪ للسليولوز و٩٦٪ للهيميسليولوز، بينما كانت ٦١٪ فى نسبة الرماد.

يوصى البحث بأن يتم إستخدام الجزء القاعدى من الساق فى صناعة الأثاث أو عجينة الورق أو إنتاج الفحم، بينما يمكن إستخدام الجزء العلوي من الساق فى إنتاج الفورفيورال والإيثانول من الخشب.