https://dx.doi.org/10.22161/ijaers.611.17 *ISSN: 2349-6495(P) | 2456-1908(O)*

Determination of physical properties of *Eucalyptus cloeziana sp.* wood in different dimensions

Lucas Abrantes Ladeira*, Arlete Barbosa dos Reis, Luiz Carlos Couto

Federal University of the Jequitinhonha and Mucuri Valleys / UFVJM - Department of Postgraduate Biofuels - Diamantina - MG – Brazil
Corresponding author:lukkas.abrantes@hotmail.com

Abstract*—The Eucalyptus belongs to the family Mirtaceae and has about 600 species with several varieties and hybrids, besides having different types of cells that adapt to perform specific functions. The objective of this study was to evaluate the physical properties of Eucalyptus Cloeziana wood, specifically, apparent density, basic density, moisture content, total volumetric retractability and anisotropy factor. The wood of this species was cut into three different sizes of species according to the current Brazilian standard, the old Brazilian standard and the French standard. The values found were similar to those found in studies of other researchers, which shows a data concordance for the Eucalyptus Cloeziana species.*
Keywords*—*Density, Forest Biomass, Retratibility.

I. INTRODUCTION

Planted forests represent an essential role in the industrial supply of wood, which shows effectiveness in replacing timber from natural forests. The favor of this scenario occurs due to the rapid growth of plantations, forest yield and technologies applied in the forestry sector [1] The Brazilian forestry is based on the cultivation and management of some species, mainly of the genus Eucalyptus that represents more than 70% of the planted forest areas, in the year 2015 corresponded to approximately 5,630,000 hectares [2].

The species Eucaliptus Cloeziana is widely applied in the civil, furniture, energy, pulp and paper sector, this way is increasingly consolidated in the industry in Brazil [3]. In addition, this tree has a rapid growth, easy management and develops in a wide variety of habitats. Eucalyptus wood has a heterogeneous structure due to variations in anatomical elements, which implies the determination of existing variation patterns for better application [4].

Eucalyptus belongs to the family Mirtaceae and has around 600 species with several varieties and hybrids, besides having different types of cells that adapt to perform specific functions. The variations existing in the chemical, physical and anatomical compositions of wood among the species are remarkable, such differences may also be present within the same species, especially as a function of age, genetic and environmental factors [5].

Among the physical properties of wood, the specific mass, one of the main parameters of application, determines the final quality and the performance of raw material in industrial and technological processes, since it is directly related to most of the other properties, as well as the cellular composition of wood [6].

The basic density of wood and the relationship between Mass and volume are directly associated with moisture content, instability of dimensions and durability [7]. The present study aimed to determine the physical properties of Eucalyptus Cloeziana wood from Diamantina-Minas Gerais, specifically regarding apparent density, basic density, moisture content, retratibility Volume and the anisotropy factor.

II. MATERIALS AND METHOD

The procedures for the determination of physical properties followed the standard ABNT NBR 7190/1997 (adapted) [12]. The wood of the species Eucalyptus Cloeziana, object of study, from the region of Diamantina-Minas Gerais was cut in three different sizes of species (Fig. 1). The dimensions were in accordance with the current Brazilian standard ABNT NBR 7190/1997 (5cm x 3cm x 2cm), the Brazilian standard NBR 7190:1982 (3cm x 2cm x 2cm), and the French Norm (5cm x 2cm x 1cm) [13].

https://dx.doi.org/10.22161/ijaers.611.17 *ISSN: 2349-6495(P) | 2456-1908(O)*

Fig 1 : Samples with different sizes

To calculate the factors associated with the physical properties of Eucalyptus Cloeziana Wood, the initial mass and the measurements of the sides of the cross section, length and width of 50 species were determined for the three different sizes. After measurements, saturation of the species was performed (Fig. 2). The wood samples were completely submerged in water around 90 days, and during this period, the water was changed weekly and the mass was verified to accompany the progression of saturation. This procedure was performed for the determination of saturated mass and volume.

Fig 2 : Saturation Analysis

Then all these bodies were subjected to a maximum temperature of 103 ± 2 º C in a greenhouse for the calculation of the dry mass and volume. During drying, the masses were checked every 6 h until there was a variation between two consecutive measurements less than or equal to 0.5% of the last mass measured for all sizes of species, this fact occurred in the third weighing.

The calculation of densities and moisture contents were performed according to the following equations involving mass and volume (Mi = initial mass (g); Mo = dry mass (g); Ms = saturated mass (g); Vi = initial Volume (cm3); Vs = saturated Volume (cm3).)

Aparent Density (g/cm³): $Dap = \frac{Mi}{Vi}$

Basic Density (g/cm³): $Db = \frac{Mo}{Vs}$

Moisture Content (%): $U = \frac{Mi-Mo}{Mo}\ x\ 100$

Maxiumum moisture content (%): $Umax = \frac{Ms-Mo}{Mo}\ x\ 100$

The calculation of total volumetric retratibility and the anisotropy factor of wood were defined from the following expressions, noting that some were determined in an analogous way. (Rv = Total Volumetric Retratibility (%); Vs = Saturated Volume of moisture (cm³); Vo = Absolutely dry Volume (cm³); Lt (Sat) = Saturated Tangential length (cm); Lt (dry) = Tangential Length

https://dx.doi.org/10.22161/ijaers.611.17 *ISSN: 2349-6495(P) | 2456-1908(O)*

absolutely dry (cm); Rt = Longitudinal Tangential retratibility (%); Rr = Longitudinal Radial retratibility (%).)

Total Volumentric Retratibility (%): $Rv = \frac{Vs-Vo}{Vs}\ x\ 100$

Longitudinal Tangential Rectractibility (%): $Rt = [Lt(sat) - Lt(dry)]\ x\ 100$

Longitudinal Radial Rectractibility (%): $Rr = [Lr(sat) - Lr(dry)]\ x\ 100$

Anisotropy Factor : $A = \frac{Rt}{Rr}$

III. RESULTS AND DISCUSSION

The mean values of the apparent density found for the three different body sizes of the test: current Brazilian norm, the old Brazilian norm and the French norm were, respectively, 0.780; 0.755 and 0.668 G/cm³ and the values of the basic density, in this order, 0.603; 0.600 and 0.541, both at 14% humidity. The mean values of the basic and apparent density of Eucalyptus Cloeziana Woods indicate that they are inserted in the class C30 of NBR 7190/1997 for structural application purposes and the figures found in the literature were similar to those obtained in this study. The species with dimensions according to the current and the old norm presented very close results and those who followed the French norm had a higher variation, however, do not interfere in the classification of wood. The following table points out the average values found (Table 1).

Table 1: Mean values for determination of the apparent densities and basic densities of EucalyptusCloeziana wood.

Samples	Apparent Density	Basic Density
(cm)	(g/cm3)	(g/cm3)
5cm x 3cm x 2cm[1]	0,780	0,603
3cm x 2cm x 2cm[2]	0,755	0,60
5cm x 2cm x 1cm[3]	0,668	0,541

[1]ABNT NBR 7190/1997; [2]NBR 7190:1982; [3]French norm

The woody materials have a large amount of water that, most of the time, it is necessary to remove before the use of raw material [8]. The high moisture content of the wood is characterized as one of the factors that causes drying defects, which can cause warings and fendilhings and, therefore, it is important to obtain little variability around the desired average moisture content [9] .The moisture content is defined as the relationship between the amount of water and the mass contained in the wood, with this, the ideal percentage depends on the application of the raw material. The tables below show the values found were very similar for the three different types of species (Table 2).

Table 2: Mean values for determination of the moisture contenst andmaximum moisture contents of EucalyptusCloeziana wood

Samples	Moisture Content	Maximum Moisture Content
(cm)	(%)	(%)
5cm x 3cm x 2cm[1]	14,547	89,672
3cm x 2cm x 2cm[2]	14,966	100,950
5cm x 2cm x 1cm[3]	14,036	113,866

[1]ABNT NBR 7190/1997; [2]NBR 7190:1982; [3]French normThe total volumetric retractibilities found for the three different sizes of the test body: Current Brazilian norm, the old Brazilian norm and the French norm were, respectively, 19.80; 17.75 and 14.98%, that is, with the reduction of the Mass, the volume was also affected [14]. It is noted that there was a significant difference between the different sizes of species with a variation of approximately 2% between the samples of the Brazilian norms and 2.77 and 4.82% when compared with the French norm. The value verified in the species of ABNT NBR 7190/1997 is in conformity with the values presented by [3] which obtained a number of 19.68%.

According to [10] the ideal anisotropy factor approximates to 1, this indicates that there was no variation or there was minimal variation in the wood dimensions or a symmetrical alteration was observed. The greater the difference between the variations of the dimensions the greater the anisotropy factor, which results in an unwanted behavior in the drying and moisture absorption processes. The anisotropy factor values found for the species of the current Brazilian norm, the old Brazilian norm and the French norm were, respectively, 1.352, 1.259 and 1.513, being within the range that qualifies this wood as excellent For use, because it does not allow for warings and Twitions [11] The following table shows the mean values found (table 3).

https://dx.doi.org/10.22161/ijaers.611.17 *ISSN: 2349-6495(P) | 2456-1908(O)*

Table 3: Mean values for determination of Total volumetric retractibilities and anisotropy factors of Eucalyptus Cloeziana Wood

Samples	Total Volumetric Retratibility	Anisotropy Factor
(cm)	(%)	
5cm x 3cm x 2cm[1]	19,80	1,352
3cm x 2cm x 2cm[2]	17,75	1,259
5cm x 2cm x 1cm[3]	14,98	1,513

[1]ABNT NBR 7190/1997; [2]NBR 7190:1982; [3]French norm

IV. CONCLUSION

The determination of the physical properties of wood allows the proper use of this raw material, in addition to preserving future problems in structural projects, making furniture, among others. The values found were similar to the studies of other researchers, which shows a data concordance for the Eucalyptus Cloeziana species. Finally, through this study, it was perceived the importance of this raw material in the present day, since it has a wide purpose and the physical properties of these materials confirms the possibility of use in various sectors.

REFERENCES

[1] Benin, C. C.; Watzlawick, L. F.; Hillig, E. Propriedades físicas e mecânicas da madeira de *EucalyptusBenthamii* sob efeito do espaçamento de plantio. ***Ciência Florestal***, v. 27, n. 4, p. 1375-1384, 2017. Disponível em: <http://www.scielo.br/scielo.php?pid=S19805098201700040 1375&script=sci_abstract&tlng=pt>. Acesso em: 09/09/2019.

[2] Indústria Brasileira de Árvores - Ibá. Disponível em: <https://www.iba.org>. Acesso em: 09/09/2019.

[3] Alves, R. C.; Oliveira, A. L. C.; Carrasco, E. V. M. Propriedades Físicas da madeira de *Eucalyptuscloeziana F. Muell*. ***Floresta e Ambiente***, v. 24, p. e00015312, 2017. Disponível em: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S2 179-80872017000100116 >. Acesso em: 09/09/2019.

[4] Tomazello F. M. Variação radial da densidade básica e da estrutura anatômica da madeira do *Eucalyptussaligna e E. grandis*.**Instituto de Pesquisas e Estudos Florestais - IPEF**, v. 29, p. 37-45, 1985.Disponível em: <http://www.ipef.br/publicacoes/scientia/nr29/cap04.pdf >. Acesso em: 01/09/2019.

[5] Trugilho, P. F.; Lima, J. T.; Mendes, L. M. Influência da idade nas características físico-químicas e anatômicas da madeira de *Eucalyptussaligna*. **Cerne**, v. 2, n. 1, p. 94-111, 1996. Disponível em: <http://www.scielo.br/scielo.php?script=sci_nlinks&ref=000 188&pid=S0104-77602014000400006000043&lng=pt >. Acesso em: 01/12/2018.

[6] Muller, B. V.; Rocha, M. P.; Cunha, A. B.; Klitzke, R. J.; Nicoletti, M. F. Avaliação das principais propriedades físicas e mecânicas da madeira de *Eucalyptusbenthamii*Maiden et Cambage. ***Floresta e Ambiente***, v. 21, n. 4, p. 535-542, 2014. Disponível em: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S2 179-80872014000400013 >. Acesso em: 09/12/2018.

[7] Sausen, G. K.; Estevão, C. I. M.; Furquim, M. C.; Araújo, S.; Oliveira, J. E. F. densidade básica da madeira de jatobá (*HymenaeaCourbaril*), pelo método de aferição do volume em imersão em água. ***Anais Colóquio Estadual de Pesquisa Multidisciplinar***,v. 1, n. 1, 2017. Disponível em: <http://www.unifimes.edu.br/ojs/index.php/coloquio/article/ view/119>. Acesso em: 08/09/2019.

[8] Donato, D. B. **Métodos de Amostragem de determinação do teor de umidade da madeira em tora**. Viçosa – Minas Gerais, 2013. Disponível em: <http://www.locus.ufv.br/bitstream/handle/123456789/3148/ texto%20completo.pdf?sequence=1 >. Acesso em: 10/09/2019.

[9] Oliveira, J. T. S.; Hellmeister, J. C.; Tomazello Filho, M. Variação do teor de umidade e da densidade básica na madeira de sete espécies de eucalipto. ***Revista Árvore***, 2005. Disponível em: <http://www.scielo.br/scielo.php?pid=S0100676220050001 0013&script=sci_abstract&tlng=es >. Acesso em: 05/09/2019.

[10] Moreschi, J. C. **Propriedades da madeira**. Curitiba, 2005. Disponível em: < http://www.madeira.ufpr.br/disciplinasmoreschi/PROPRIED ADES%20DA%20MADEIRA.pdf >. Acesso em: 09/09/2019.

[11] Rodrigues, T. O.; Rousset, P. L. A. Effects of torrefction on energy properties of Eucalyptus grandis wood. **Cerne**, v. 15, n. 4, p. 446–452, 2009.

[12] Associação Brasileira de Normas Técnicas. NBR 7190: Projetos de estruturas de madeira – Rio de Janeiro, 1997.

[13] Norma Francesa NF P 51 – AFNOR (Association Française de Normatisation).

[14] Metcalfe, C. R.; Chalk, L. Anatomy of the dicotiledons, wood structure and conclusion of the general introduction. Oxford: Clarendon, 1983. 297 p.