VARIATION OF THE TECHNOLOGICAL PROPERTIES OF WOOD FROM *Ochroma pyramidale* IN THE LONGITUDINAL AND RADIAL SENSE OF THE SLEW

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Received for publication: 17/04/2020 – Accepted for publication: 04/05/2021

Resumo

Variação das propriedades tecnológicas da madeira de Ochroma pyramidale no sentido longitudinal e radial do fuste. O trabalho teve como objetivo caracterizar a madeira da espécie *Ochroma pyramidale* no sentido longitudinal e radial da árvore. Para a realização do estudo foram utilizadas cinco árvores, com idade de seis anos. Discos foram retirados em diferentes alturas do fuste. De cada disco foram obtidas amostras em diferentes regiões entre a medula e casca. A preparação e análise anatômica das lâminas permanentes e provisórias, as análises químicas e a densidade básica da madeira do fuste foram realizadas conforme normas técnicas. Como resultados observou-se que as maiores médias para diâmetro dos poros e comprimento das fibras foi encontrada na região próxima da casca em todas as alturas da árvore. Em relação aos raios, nota-se que houve interação entre os fatores longitudinal x radial para a maioria dos parâmetros avaliados, exceto para a largura dos raios. Para diâmetro do lume da fibra e comprimento do vaso, foi encontrado uma mesma linha de tendência, a maior média observada na região próxima da medula. Nas análises químicas foi possível observar que não houve diferença significativa no sentido longitudinal da madeira apenas para solubilidade em água fria. Para densidade básica verificou-se um acréscimo na região próxima a medula para região próxima a casca, ainda, em relação a posição longitudinal do fuste foram encontrados os maiores valores na base do fuste. Pode-se verificar que a espécie *Ochroma pyramidale* possui potencial de uso para produtos vinculados ao isolamento térmico e acústico, produção de painéis aglomerados e celulose e papel.

Palavras-chave: densidade básica, caracterização anatômica, química, fibra, raio.

Abstract

The work aimed to characterize the wood of the species *Ochroma pyramidale* in the longitudinal and radial direction of the tree. For the study, five six-year old trees were used. Discs were removed at different heights of the stem. The samples were obtained from each disk in different regions between the pith and bark. The preparation and the anatomical analysis of the permanent and temporary slides, chemical analyzes, and basic density measure of the stem wood were carried out according to technical standards. As a result, it was observed that the highest averages for pore diameter and fiber length were found in the region close to the bark at all heights. Regarding to the rays, it was noted that there was an interaction between the longitudinal x radial factors for most of the parameters evaluated, except for the width of the rays. For fiber lumen diameter and vessel length, the same trend line was found, the highest average observed in the region close to the pith. In the chemical analyzes, it was possible to observe that there was no significant difference in the longitudinal direction of the wood except for solubility in cold water. For basic density, there was an increase in the region closer to the pith compared to the region closer to the bark. However, in relation to the longitudinal position of the bole, the highest values were found at the base of the bole. It could be seen that the *Ochroma pyramidale* species has potential use for products linked to thermal and acoustic insulation, production of particleboards and pulp and paper production.

Keywords: basic density, anatomical characterization, chemistry, fiber, rays.

INTRODUCTION

The species *Ochroma pyramidale* (CAV. EX LAM.), belonging to the Malvaceae family, is popularly known as pau-de-balsa, balsa, pau-de-jangada. Its area of occurrence ranges from southern Mexico to Bolivia, Peru and Brazil, preferably in lowlands and in valleys between mountains, but it can also be found up to 2000m in altitude. It occurs in primary and secondary forests. It develops relatively well in sandy soil with a thin organic layer, such as on the flooded banks of rivers and igapós, but it prefers fertile, moist, well-drained, clayey, neutral or alkaline soils and does not tolerate high salinity soils (LEÃO *et al.* 2008).

This tree has a short life, entering senescence at 12 years of age, has fast growth and can reach the forest canopy, with 20 to 25 m in height and up to 1.2 m in diameter, the crown is open and wide and can reach up to 18 m in diameter (LEÃO *et al.* 2008). *Ochroma pyramidale* wood is generally very light, with low density, according to the IPT classification (1985). The density of this species is variable and is mainly linked to the age and habitat of the tree. The basic wood density of this species varies between 0.060 and 0.350g/cm³ (WEIRICH, 2011). Still, the species *Ochroma pyramidale* has a shorter rotation cycle when compared to other forest species, such as *Pinus spp* and *Eucalyptus spp*. Along with that, the study of the species has a positive point because it becomes its more profitable cultivation.

For the use in the industry of *Ochroma pyramidale* or any other species, a deeper knowledge of the characteristics belonging to wood is necessary. This knowledge must be realized due to the variations that wood presents both from the pith to the bark (radial direction) and from the base to the top (longitudinal direction) for the anatomical elements and also for the physical, mechanical and chemical properties. From the information on the characteristics of the species, it is possible to define the best way to process the wood in order to increase the yield of the product and achieve better added value.

There is a need for the studied species to be submitted to further research regarding its management, forestry and potential use of its wood. The various uses of this type of wood coincide with the need to obtain a material with low density, making it necessary to evaluate the properties of trees from homogeneous plantations.

In the literature, studies with other species addressing longitudinal and radial variation are quite frequent, as is the case of Jesus & Silva (2019), studying the radial variation of the anatomical and physical properties of eucalyptus wood. And also Araújo *et al.* (2016), who presented in their results the variations in the physical properties of the wood of *Calycophyllum spruceanum* Benth., because of the diameter and the position in the base and top direction.

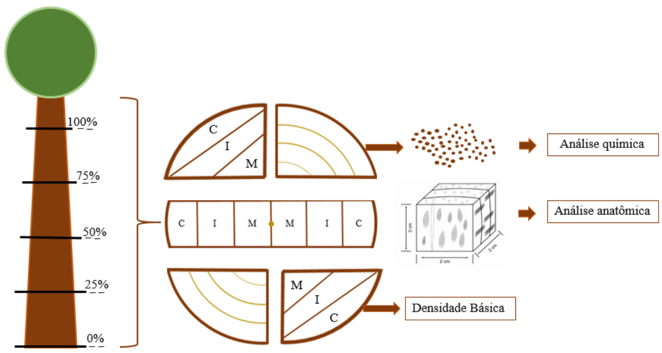
In recent times, there has been a need to develop new sources of raw material for the forest sector to complement or replace exotic species. Therefore, the wood of *Ochroma pyramidale* becomes an alternative, mainly for uses that require low specific mass, such as the production of agglomerated panels. Given the above, the present study was carried out with the aim of characterizing the anatomical structure, chemical composition and determining the variation in the basic density of *Ochroma pyramidale* wood in the longitudinal and radial direction of the shaft.

MATERIAL AND METHODS

Raw-material

To carry out the study, five randomly sampled trees of the species of *Ochroma pyramidale*, aged six years, from reforestation located in the municipality of Mira Estrela, northwest of the state of São Paulo (Latitude: 19º 56' 08.03" S; Longitude: 50º 09' 48" W).

Five-cm thick discs were removed from the trunk of the trees in the longitudinal positions of the bole of 0%, 25%, 50%, 75% and 100% in relation to the commercial height (0.08 m of limit diameter) of the tree. These discs were used for anatomical and chemical analysis and determination of basic wood density (Figure 1).



Where: C: region close to the shell; I: intermediate region; M: region close to the spinal cord.

Figure 1. Sampling to study the properties of *Ochroma pyramidale* wood.
Figura 1. Amostragem para estudo das propriedades da madeira de *Ochroma pyramidale*.

Anatomical analysis of wood

The specimens were saturated to facilitate histological cuts. Subsequently, using the slide microtome, the samples were obtained from the sections in the three anatomical planes (transverse, radial and tangential) with an average thickness of 16 µm. The histological sections were placed in an alcoholic and alcohol-acetate sequence. Also, for making and preserving the cuts, Entellan was used as a synthetic adhesive in the preparation of permanent blades. For each anatomical character, 1800 repetitions were measured.

The macerated material was obtained from the dissociation of wood elements, following Franklin's methodology (1945). Measurements of anatomical elements were performed using the Leica Module Leica LAS Interactive Measurements software, following the procedures of Iawa Comittivee (1982).

Chemical analysis of wood

For the chemical analysis, the opposite wedges were removed from the discs in the longitudinal positions of the shaft of 0, 25, 50, 75 and 100%, transformed into chips by means of a chipper and then crushed in a Willey type mill. The material was stored in an air-conditioned chamber, with a constant temperature of 20±2ºC and a relative humidity of 65±3%, up to constant mass, with an equilibrium moisture content close to 12%. Afterwards, the sawdust went through 40-60 mesh sieves. The sorted sawdust from the two opposite wedges of each disc was homogenized and 3 samples were taken per disc as a repetition. The chemical analyzes were carried out according to the respective standards: extractive content in water (NBR 7988, ABNT/1984); extractive content (NBR 14660, ABNT/2004); solubility in 1% NaOH (NBR 7990, ABNT/2010); ash content (TAPPI T222 om-08/1993); lignin content (TAPPI T413 om-06/1993).

Determination of basic density

The basic density was obtained according to the NBR 11941 regulation (ABNT, 2003). The wedges were cut from the discs of five trees, in the stem positions of 0, 25, 50, 75 and 100%, with 5 cm of thickness. The discs were cut into two wedges and delimited the regions of bark, intermediary and pith.

Statistical analysis

The data analysis was performed in a randomized block design, factorial 5x3, considering the longitudinal direction of the shaft (0, 25, 50, 75 and 100%) and the radial direction of the trunk (bark, intermediate and pith). To test the adherence of data to normal distribution, the Kolmogorov-Smirnov test was performed for sets with more than thirty (30) data, whereas the Shapiro Wilk test was used for analyzes with less than thirty (30) data. In turn, to test the homogeneity of data, the Bartlett test was performed. Data that did not present normal distribution needed to be transformed, for this, a box-cox type transformation was used. Once all the assumptions met, the analysis of variance and Scott-knott test were performed at a 95% confidence level, using the software Sisvar 5.6 Build 77 and the Action platform of the Excel program.

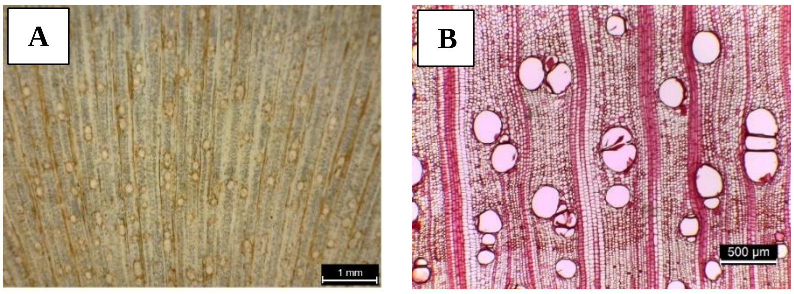
RESULTS

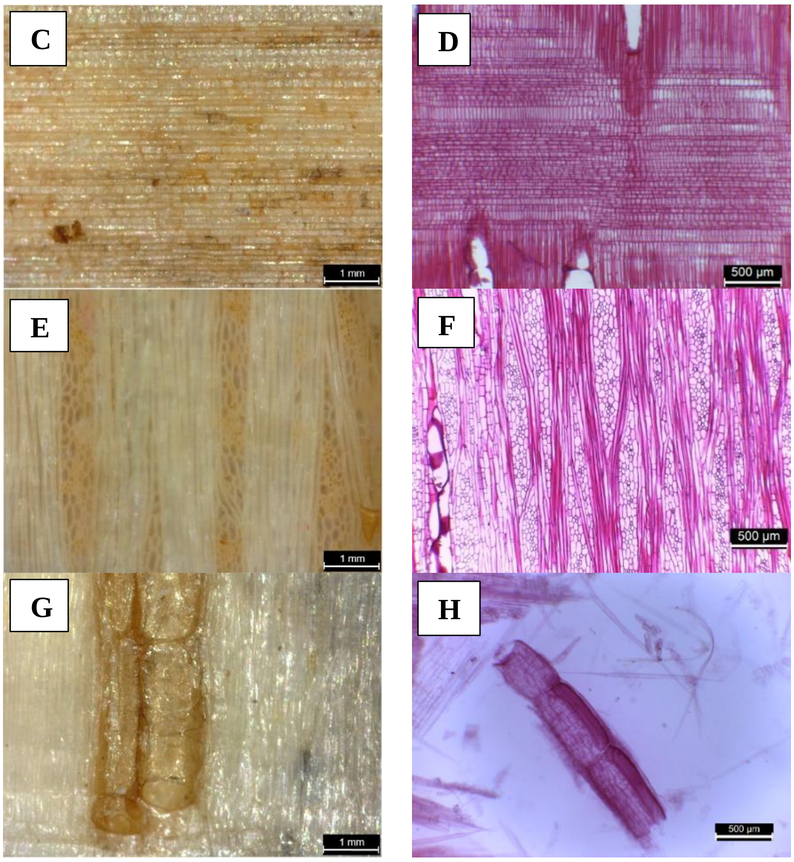
Trees of the species *Ochroma pyramidale* had mean diameter at breast height (DBH); commercial height and total height of 21.7cm; 16.8m and 18.5m respectively.

Anatomical description of the wood of the species *Ochroma pyramidale*

Macroscopic features: Growth layers and axial parenchyma: distinct. Rays: visible to the naked eye. Pores: Visible, solitary and multiple.

Microscopic features: Wood: with diffuse porosity (Figure 2/A), little distinct growth rings. Vessels: circular, mostly solitary, but also present in a twinned form in radial multiples of 2 to 8 units (Figure 2/B). Vascular elements with simple perforation plates (Figure 2/G and H). Intervessel scores are alternate. Axial parenchyma: sparse paratracheal and diffuse apotracheal aggregate. Rays: Heterocellular and multiseriate (Figure 2/E and F), showing procumbent and quadratic cells. Fibers: Libriformes not septate. Absence of helical thickening. Other characters: Presence of aggregated rays and toothed fibers. Absence of glandular cysts, mucilaginous cells and medullary macules.





Where: A – Cross section macroscopy. B – Diffuse porosity. C – Macroscopy of the radial section. D – Heterocellular rays. E – Macroscopy of the tangential section. F – Distribution of rays. G – Macroscopy of the vessel element. H – Vessel element (macerated). Bars: A, C, E and G = 1mm; B, D, F and H = 500µm.

Figure 2. Macroscopic planes and elements of the species *Ochroma pyramidale*.
Figura 2. Planos macroscópicos e elementos da espécie *Ochroma pyramidale*.

Table 1 shows the maximum, minimum, mean, standard deviation and coefficient of variation of all anatomical parameters evaluated for the species under study.

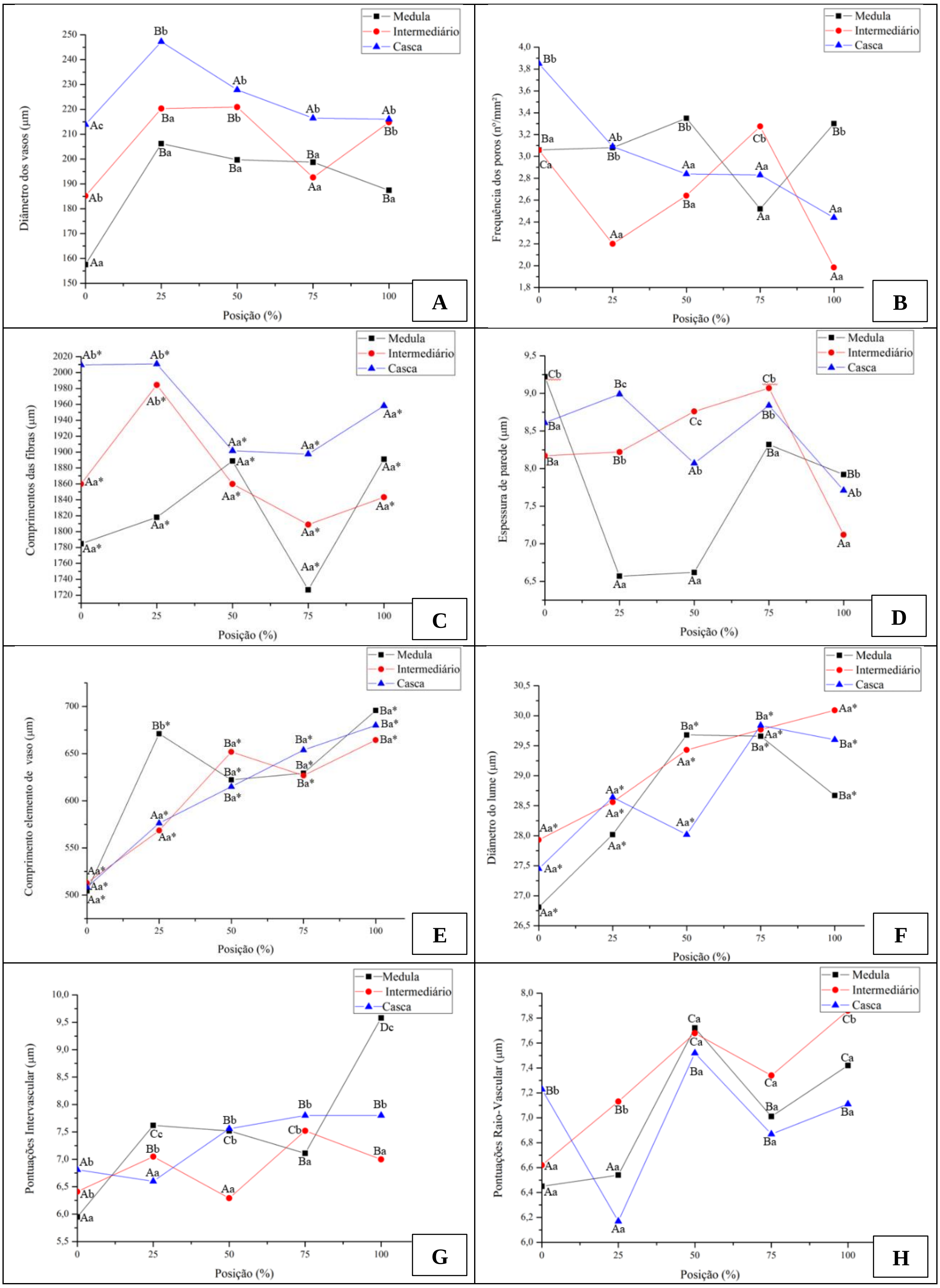
Table 1. Anatomical parameters.
Tabela 1. Parâmetros anatômicos.

Anatomical Parameters	**Maximum**	**Minimum**	**Average**	**DP**	**CV (%)**
Vessel diameter (µm)	396,82	83,35	205,62	40,20	19,55
Pore frequency (nº/mm²)	19,00	2,00	2,89	1,91	66,30
Fiber length (µm)	2964,04	510,14	1860,56	307,42	16,53
Wall thickness (µm)	16,62	2,37	8,14	2,47	30,28
Length of vessel element (µm)	971,12	79,33	601,99	131,98	21,92
Diameter of fire (µm)	61,34	10,84	28,86	6,95	24,07
Diameter of intervessel pits (µm)	18,93	1,99	7,22	1,79	24,87
Diameter of vascular radius scores (µm)	13,64	1,78	7,10	1,83	25,81
Height of rays (µm)	2440,96	24,89	1188,16	490,87	41,31
Radius width (µm)	448,56	11,67	111,27	56,71	50,96
Radius frequency (nº/linear mm)	14,00	2,00	2,89	1,84	63,80

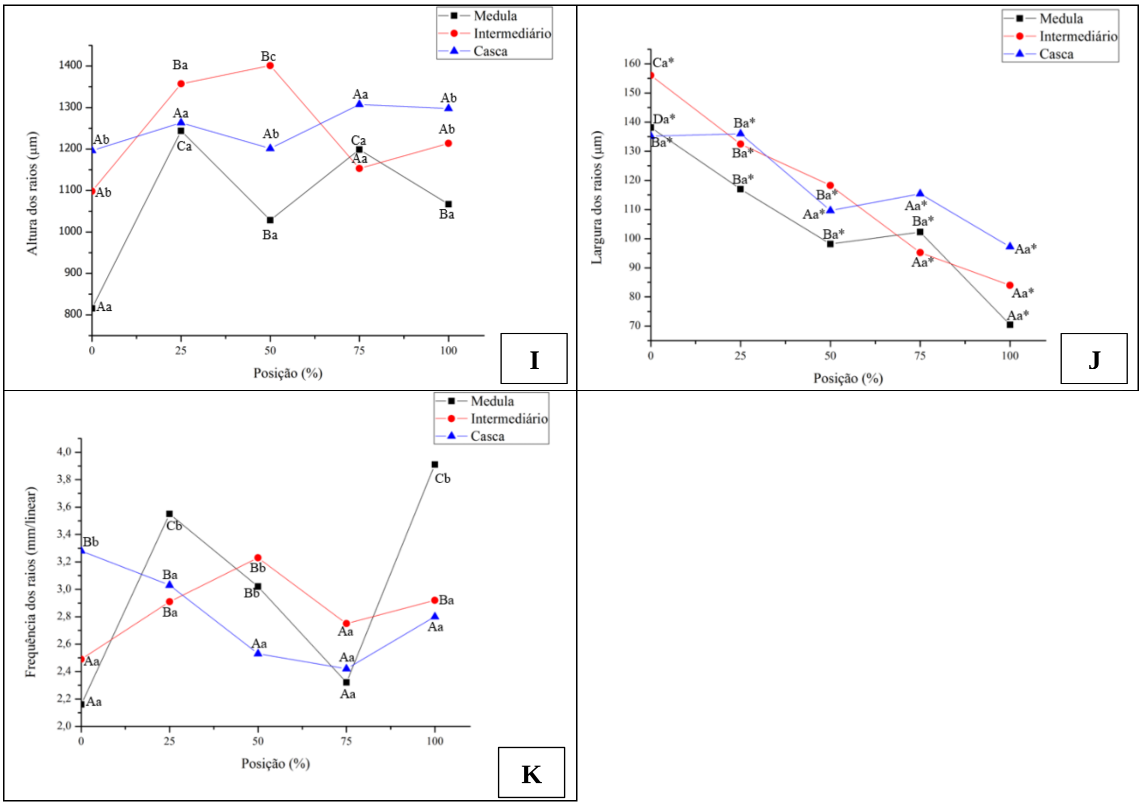
Where: DP: Standard deviation; CV: Variation Coefficient.

Quantitative anatomical analysis of wood

The anatomical parameters: vessel diameter, pore frequency per linear millimeter, fiber wall length and thickness, vessel element lumen length and diameter, diameter of intervascular and vascular ray punctuations, ray height and width and frequency of radii per linear millimeter were shown in figure 3.



ISSN eletrônico 1982-4688
DOI: 10.5380/rf.v51 i4. 72952



Where: A – Diameter of vessels (µm); B – Pore frequency per linear millimeter (nº/mm²); C – Fiber length (µm); D – Wall thickness (µm); E – Length of the vessel element (µm); F – Diameter of the fire (µm); G – Diameter of intervessel pits (µm); H – Diameter of vascular-ray scores; I – Height of rays (µm); J – Radius width (µm); K – Frequency of rays (mm/linear).

Also: Means followed by equal letters do not differ from each other by the Scott-Knott test at 5% significance. Capital letters are considered the longitudinal direction, while lowercase letters are considered the radial direction. *Variable in which the interaction between longitudinal x radial factors was not significant at the 5% significance level.

Figure 3. Quantitative anatomical parameters of the wood of the *Ochroma pyramidale* species along the radial and longitudinal planes.

Figura 3. Parâmetros anatômicos quantitativos da madeira da espécie de *Ochroma pyramidale* ao longo dos planos radial e longitudinal.

Table 2 shows the mean values of each chemical analysis performed in the present study.

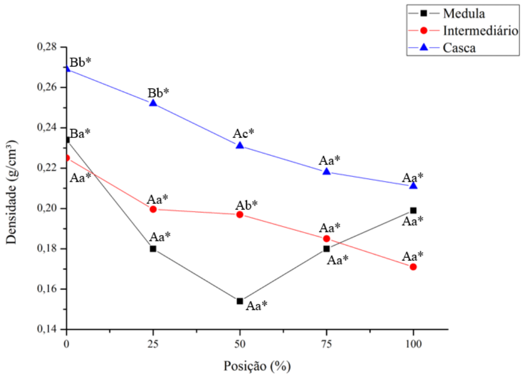
Table 2. Solubility of extractives in cold water, hot water, NaOH, total extracts, lignin, ash and holocellulose.

Tabela 2. Solubilidade de extrativos em água fria, água quente, NaOH, extrativos totais, lignina, cinzas e holocelulose.

Longitudinal Position (%)	AF	AQ	NaOH	ET	L	C	H
				(%)			
0	1,88 **a** (23,56)	2,42 **a** (6,60)	18,08 **a** (5,85)	4,24 **a** (5,40)	16,45 **c** (26,81)	1,53 **a** (1,69)	77,76 **a** (5,65)
25	2,41 **a** (18,65)	2,41 **a** (3,79)	17,44 **a** (3,93)	3,65 **a** (9,16)	23,18 **b** (11,27)	1,38 **b** (0,67)	71,77 **b** (3,19)
50	2,08 **a** (7,12)	2,52 **a** (9,37)	16,19 **b** (2,96)	3,82 **a** (19,60)	29,34 **a** (8,38)	1,39 **b** (13,54)	64,68 **c** (12,96)
75	1,76 **a** (15,62)	1,98 **b** (16,44)	15,09 **b** (4,68)	3,26 **b** (6,83)	16,89 **c** (12,42)	1,57 **a** (0,66)	79,09 **a** (2,33)
100	2,07 **a** (21,89)	1,87 **b** (16,26)	17,44 **a** (6,97)	2,68 **b** (35,68)	14,93 **c** (14,28)	1,14 **c** (13,73)	81,23 **a** (0,92)
Mean	**2,04**	**2,24**	**16,84**	**3,53**	**20,15**	**1,40**	**74,90**

Where: AF: cold water; AQ: hot water; NaOH: sodium hydroxide; ET: total extractives; L: lignin; C: ash; H: holocellulose. Means followed by equal letters do not differ from each other by the Scott-Knott test at 5% significance. Lowercase letters analyze the position in the longitudinal direction. In parentheses, the coefficient of variation is expressed.

The results of basic density in the longitudinal and radial directions of the wood of the species *Ochroma pyramidale* were expressed in figure 4.



Means followed by equal letters do not differ from each other by the Scott-Knott test at 5% significance. Capital letters consider the position in the longitudinal direction, while lowercase letters analyze the region in the radial direction. *Variable in which the interaction between longitudinal x radial factors was not significant at the 5% significance level.

Figure 4. Basic wood density of *Ochroma pyramidale*.
Figura 4. Densidade básica da madeira de *Ochroma pyramidale*.

DISCUSSION

Quantitative anatomical analysis of wood

As seen in figure 3/A-B, both radially (medulla-bark) and longitudinally (0% - 100%) showed a significant difference for vessel diameter and frequency. Analyzing the radial regions, we can observe that there was an increase in the diameter of the vessels in the pith-bark direction. For the vessel frequency, the behavior was inverse, where values decreased in the pith-bark direction for positions 50% and 100% along the shaft. The medulla has a greater number of vessels with a smaller diameter, due to the lower physiological activity in this position. This inversely proportional relationship between these two anatomical characters (vessel diameter and frequency) occurs because, the closer to the cambium, the greater the need to transport water and nutrients, thus influencing the lower frequency and larger diameter of vessels (TOMAZELLO FILHO, 1987). This inverse trend was also observed in studies with *Ochroma pyramidale* by Lobão *et al.* (2011), however, the authors found much higher values for pore diameter, 812.84 µm, and lower values for vessel frequency, 0.19 n/mm.

Regarding the length of the fibers, it can be observed (Figure 3/C) that there was no significant difference in the longitudinal direction of the wood, that is, they resulted in statistically equal means. The trend observed for this anatomical character was the presence of longer fibers at the base of the shaft (0 and 25%) for the intermediate region and shell. For pith, the longest fibers were observed at the top of the shaft (100%). Furthermore, there was an increase in the pith-bark direction for fiber length. As for wall thickness, the opposite occurred, the thickest walls were found at the top of the shaft (75%) for the intermediate and shell directions. For the medulla, the thickest wall was found at the base of the shaft, at the 0% position. The mean value found for wall thickness was 8.14µm, that is, the result for this anatomical character was higher than that found by Lobão *et al.* (2011), equivalent to 4.24µm for the same studied species. The greater the thickness of the wall, the greater the density of the wood, providing better results in the properties of strength and stiffness of the wood. Thus, wall thickness is related to wood quality (ANDRADE *et al.* 2019).

Studies by Trevisan *et al.* (2013), observed a behavior similar to the present study, in which they presented a trend of greater dimensions for the length of the fibers in the pith-bark direction.

According to studies by Trevisan *et al.* (2013), the variability of fiber length in the radial direction is explained by the presence of a juvenile wood zone close to the pith, which presents, among other characteristics, short fibers, with smaller diameter, narrower walls and larger fibrillar angle in the S2 layer, which directly affects the quality of the wood. Regarding to the length of the fibers, we can observe that they are long and possibly have the potential for the production of high quality pulp with a degree of yield between 45 and 50% (WEIRICH, 2011).

In the studies by Lobão *et al.* (2011), evaluating the characteristics of *Ochroma pyramidale* fibers, similar values were found compared to the present study, for fiber length, equal to 1929.58µm.

The behavior for the variables of vessel element length and fire diameter were similar. It was possible to verify that for both variables there was an increase in their dimensions along the shaft for all directions (medulla-bark).

In figure 3/G, we can analyze that for the diameter of the intervessel pits there was a significant difference in both directions of the wood, radially and longitudinally, with a variation from 5.95 to 9.58μm. As for the diameter of the ray-vascular punctuations (Figure 3/H), there was a significant difference in the longitudinal direction of the wood, a behavior not found in the radial direction, where the means did not differ from each other in the heights of the bole of 50 and 75%. The variation in the diameter of the vascular-ray punctuations ranged from 6.17 to 7.86 μm.

The trend found for the diameter of the intervessel pits was the occurrence of an increase along the shaft. For the diameter of the vascular ray punctuations, the peak with the largest diameter was observed in the middle of the bole, at a height of 50% for the different regions (marrow-bark).

We can notice in figure 3/I that, for the variable height of the rays, there was a significant difference in the longitudinal direction of the wood, except when close to the bark. For the radial direction, the means did not differ from each other at the heights of 25 and 75%. For the variable width of the rays, there was a significant difference in the longitudinal direction of the wood, a behavior that was not found in the radial direction (Figure 3/J).

The behavior observed for the height of the rays was a significant increase in the dimensions of the rays from the 0% position to 25%, for the intermediate region and pith. Regarding the width of the rays, it was possible to observe a decrease in the dimensions of the rays along the shaft.

Note that there was a significant difference for the variable frequency of rays per linear millimeter (Figure 3/K) in the longitudinal direction of the wood. In the radial direction, the height of 75% was the only one that presented similar means to each other. Also, the maximum and minimum values found for this parameter were 3.91 and 2.16/mm linear. According to Maranho *et al.* (2006), changes in the cell dimensions may be correlated with corresponding changes in the organization of the cell wall, which is associated with the orientation angle of the microfibils present in the S2 layer of the secondary wall.

Gonçalves and Lelis (2011), studying the low basic density of *Acacia mangium* species (in the order of 0.34g/cm³) along the shaft, found a variation of 119.82 to 159.89μm for the height of the rays and 4 .89 to 6.66μm for radius width. For lightning frequency per linear millimeter, the variation was from 5.11 to 5.77.

Wood chemistry

According to the chemical analyzes presented in Table 2, it was possible to observe that for most of the analyzes there was a significant difference in the longitudinal direction in the wood only for the analysis of solubility in cold water that showed similar means, not differing from each other. The mean values found for the analysis of cold and hot water were 2.04 and 2.24%, respectively. Water-soluble wood components include inorganic salts, sugars, low molecular weight polysaccharides, cycloses and cyclitols, and some phenolic substances. Furthermore, some of the water-soluble components are partially soluble in many organic solvents and vice-versa (SARTO & SANSIGOLO, 2010).

According to the sodium hydroxide solubility analysis for *Ochroma pyramidale* wood, the average value found was 16.85%, that is, the species has high solubility. This type of analysis indicates the degree of degradation of cellulose by light and oxidation given by woody organisms. The lower the solubility, the lower the degradation and, consequently, the greater the natural durability of wood (TOMAZELI *et al.* 2015).

For the total extractives, an average value of 3.53% was found. Still, it can be observed that, along the bole, the value of total extractives decreased. The lignin values ranged from 14.93% to 29.34%, with an average value equivalent to 20.15%, with a high coefficient of variation between samples. The content of holocellulose present in the material resulted in an average value of 74.90%. Analyzing these results, the studied species chemically presents potential for the production of cellulose. However, it is noteworthy that other factors must be evaluated to materialize this indication of use of the species, such as evaluating the morphology of the fibers, in order to verify the quality parameters in the production of pulp.

Lobão *et al.* (2011), studying the chemical characteristics of the same species, aged 7 years, found similar values when compared to the present study, 4.75% for extractives, 25.61% for lignin and 69.64% for holocellulose. The wood of *Ochroma pyramidale* presented an average value of ash content equivalent to 1.40%. The amount of ash is the result of mineral constituents removed from the soil. Woods growing naturally in temperate zones contain from 0.2 to 0.9%, while wood from tropical zones can contain up to 5%.

Basic density

In figure 4, there was a variation in basic density from 0.154 to 0.269 g/cm³. Furthermore, a statistical difference was observed between the means in the longitudinal direction close to the bark and pith. In the radial direction, it was possible to verify that the means did not differ statistically in heights of 75% and 100%. The highest density values were found at the base of the shaft (0% and 25%).

The behavior of the basic density of the wood along the bole was decreasing in the bark and in the intermediate region. The reduction in specific mass may be a result of the size of the fiber cell walls or the difference in proportion between the thickness of fibers and vessels (NISGOSKI *et al.* 2011).

Also, higher density values were observed in the shell region. This behavior is proven in studies by Sangumbe & Alberto (2020). The species fits into a low-density wood, according to the IPT classification (1985). Anatomical characters such as pore diameter and frequency directly influence this variable, and wood has many empty spaces resulting in a low density.

The properties of wood vary according to the growth radius, fast-growing species such as the species of *Ochroma pyramidale*, reach commercial dimensions at a very young age, even before the formation of adult wood. Thus, the portion of the wood corresponding to the wood juvenile fibers have shorter and less dense fibers (SILVA JÚNIOR *et al.* 2011).

In the study by Lobão *et al.* (2011), determining the basic density of the species *Ochroma pyramidale*, it was found values similar to those in the present study, equivalent to 0.20 g/cm³. Oliveira *et al.* (2017), also studying the species of *Ochroma pyramidale* at different ages, found basic density values of 0.195 g/cm³ (4 years) and 0.239 g/cm³ (14 years).

Species that present density below 0.48 g/cm³ are of greater interest to the pulp industry (SILVA JUNIOR *et al.* 2011). Studies by Queiroz *et al.* (2007) found that woods of lower density provide less resistance to cutting, generating chips of smaller thickness, facilitating the impregnation by the cooking liquor, improving yield and reducing expenses related to knives and energy consumption. However, when it comes to the use of wood aimed at the production of pulp, it is necessary to carry out more in-depth analysis.

The low density of *Ochroma pyramidale* wood is also favorable for the production of agglomerated panels, since species with low density are commonly recommended so that an ideal compaction ratio of the panel can be achieved.

CONCLUSION

The characterization of *Ochroma pyramidale* wood in the longitudinal and radial directions presented the following parameters:

- Smaller pore diameter observed at the base in relation to the top and inverse behavior for pore frequencies, that is, these are less frequent at the base.
- Greater fiber lengths were found at the base of the shaft (0 and 25%), except for the medulla region. The trend for wall thickness was the opposite, the thickest walls were found at the top of the shaft (75%) for the intermediate region and shell.
- The rays showed a decrease in width along the shaft;
- Based on the chemical analysis of the wood, it can be concluded that it had a high solubility in NaOH (16.85%), resulting in a greater probability of attack by xylophagous agents in the wood. Still, it presented potential values of holocellulose (74.90%) and lignin content (20.15%), aimed at the production of cellulose.
- Basic density was included in the classification of wood as a low density species. However, in relation to the radial behavior of wood, an increase in values can be observed from the region close to the pith to the region close to the bark.

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