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Wood anatomical characterization and intraspecific variation in *Protium apiculatum* Swart at the second forest management cycle

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RESUMO A Floresta Nacional do Tapajós teve seu primeiro ciclo de corte em 1979 e a área foi monitorada através de inventários florestais desde então. Neste período houve mudanças na composição florística, com *Protium apiculatum* Swart sendo uma das espécies mais abundantes e frequentes. No entanto, não existem estudos das suas características tecnológicas da madeira. Assim, o estudo teve como objetivo caracterizar anatomicamente cinco árvores dessa espécie. Discos de madeira de foram coletados a dois metros de altura de cada árvore, o material foi separado para análise macroscópica e microscópica. Através dos resultados obtidos, percebeu-se variação intraespecífica entre os caracteres anatômicos de *Protium apiculatum* em um mesmo local e similaridade com outros indivíduos de seu gênero.

Palavras-chave: anatomia da madeira, tecnologia da madeira, microscopia, FLONA – Tapajós, Floresta Amazônica.

Caracterização anatômica e variação intraespecífica da madeira de *Protium apiculatum* Swart do segundo ciclo de manejo florestal

ABSTRACT Tapajós National Forest had their first cutting cycle in 1979 and the area has been monitored through forest inventories since then. In this period, there were changes in floristic composition, with *Protium apiculatum* Swart being one of the most abundant and frequent species. However, there are no studies of the technological characteristics of its wood. Thus, the study aimed to characterize five trees of that species as to their anatomy. Wood disks were collected from each tree at a height of two meters, and the material was separated for macroscopic and microscopic analysis. The obtained results revealed intraspecific variation between the anatomical characters of *Protium apiculatum* in one location and similarity to others of its genus.

Keywords: wood anatomy, wood technology, microscopy, FLONA - Tapajós, Amazon Forest.

Introduction

The Tapajós National Forest has great importance for scientific studies in the areas of biodiversity and forest management. According to Costa Filho (1980), to develop a study on forest harvesting an evaluation of environmental impacts should be included. Thus, EMBRAPA Eastern Amazon has been monitoring the experimental area of FLONA Km 67 since 1975. In 1979, the first cutting cycle occurred in this area.

After three decades of postharvest monitoring, *Protium apiculatum* Swart (Burseraceae) became one of the most abundant and dominant tree species in this experimental area (Reis et al., 2010).

According to Silva; Lopes (1984), forest management is an instrument capable of reconciling the sustainable use of forest resources with the conservation of ecosystems as it will not cause irreversible damage to the forest ecosystem.

Soffiatti; Angyalossy-Alfonso (1999) explain that wood anatomy analysis has been consolidated as an important tool

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in solving taxonomic, evolutionary and ecological issues, and studies to support solutions inherent to taxonomic problems have been carried out since the eighteenth century (Pinheiro; Carmo, 2009). However, the potential of these techniques is hardly ever used in Brazilian Amazonia.

According to Metcalf; Chalk (1957), the variation which occurs between trees of the same species could happen due to the ecological condition of the site, as well as to the genetic variability of the same taxon. In that way, Alves; Angyalossy-Alfonso (2000) state that the vessels can present grouping in dry environment, although grouping rarely happens in wet environment, where the same variation can occur in different altitudes. Thus, the descriptive and ecological anatomy of wood helps understanding these variations.

In this way, Daly (1992) cites *Protium* Burn f. as an important genus in Amazonia due to its diversity, where 73 species occur, 42 of them being endemic to the region. Most of these are understory trees in the primary forestry and the tree is commonly known as "breu" (MELO et al, 2007; DALY, 1992). The present paper aims to characterize *Protium apiculatum* wood anatomically and analyze it for quantitative variations of anatomical elements in different trees of the species.

Material and Methods

The study material was collected in the EMBRAPA's experimental field in the Tapajós National Forest at km 67 of BR163, Cuiabá-Santarém, at coordinates 55°00' W, 2º45' S. The total area is 210ha and the area of the first cutting cycle covered 64ha.

The climate is classified as Ami in the Köppen system, i.e., tropical humid with annual temperature variation of less than 5 °C. In the Gaussen system, the climate is classified as Xerothermic, presenting lower temperatures above 15 °C and a dry period of 40 days. The average annual temperature is 25.5 °C, with a maximum of 30.6 °C and a minimum of 21.0 °C. The observations were made between 1988 and 2003, at the climatological station of Belterra. (IBAMA, 2004).

In the experimental area of 64 ha, samples were collected from five *Protium apiculatum* trees. Disks for anatomical analysis were removed at a height of two meters. Plant material for scientific identification of the species was brought to Eastern Amazon EMBRAPA, where the samples were registered and identified with the help of herbal experts from the Federal University of Western Pará.

The wood slides were cut with the aid of a manual microtome, American Optical Corp. brand, model 36H. Histological sections were 15μm thick in the radial and tangential longitudinal plans and 20μm for the transverse plane. Subsequently, the material went through a clarification process in sodium hypochlorite at 2.5%, safranin staining and in alcoholic dehydration (Johansen 1940). Finally, the material was kept in butyl acetate until the permanent slides were assembled in Canada balsam.

Hydrogen peroxide and acetic acid in the ratio 1:1 were used for the macerate, and the sample was kept in a chamber at 60 °C for sufficient time for the dissociation of anatomical elements, a process indicated to whitish timber (Franklin, 1945).

The anatomical characteristics were analyzed according to the methodology of the International Association of Wood Anatomists (IAWA, 1989). For each anatomical element analyzed, 50 repetitions were performed due the high variability that occurs in the region.

To obtain fiber, vessel and radius images in all three planes and in the homogenized material, a trinocular microscope coupled to a digital camera model T1004772 was used. The images were obtained with Belview software, version 6.2.3.0, and the measurement was performed with the use of the program IPWin32, version 4.5.0.29.

For statistical analysis, we compared means with Scott-Knot with the program Variance Analysis System - SISVAR.

Results and Discussion

The wood of *Protium apiculatum* presents vessels with diffuse porosity; diagonal and/or radial and predominantly solitary vessels (83,44%), occasional multiple of two and three (9,79 to 5,97%) and rare multiples of four (0,80%). The vessels present circular and oval outline (Figure 1), an average tangential diameter of 107 (±23,39) µm, vascular elements with an average length of 291µm (±78,18), simple perforation plate and alternate intervessel pits. Vasicentric axial parenchyma.

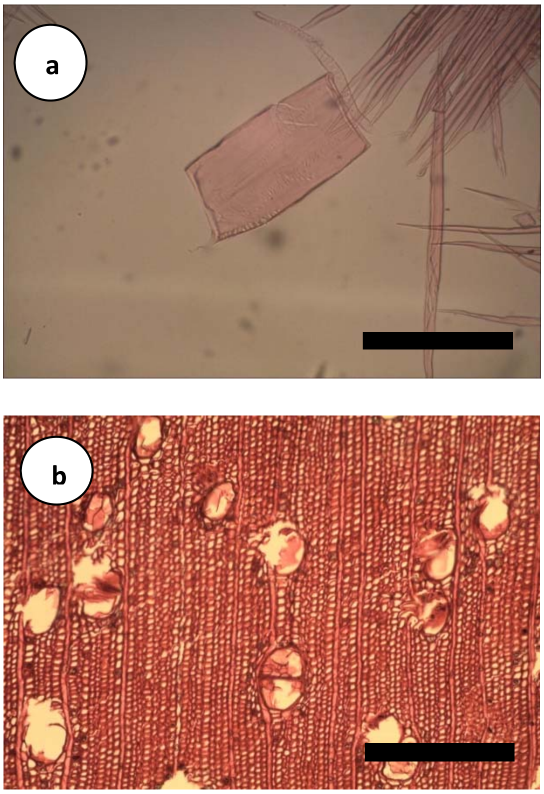

Figura 1. Caracteres anatômicos da *Protium apiculatum* Swart. **a** - vaso macerado; **b** - seção transversal. Escala - 150µm.
Figure 1. Anatomical characters of *Protium apiculatum* Swart. **a** - macerated vessel; **b** - cross-section transversal. Bar - 150µm.

The results obtained for vessel tangential diameter are similar to the ones found in the *Protium aracouchini* and *Protium grandifolium* studied by León (2002), except for vessel length of *Protium grandifolium*, where he found a value close to 371µm. According to Schweingruber (2007), Denardi; Marchiori (2005) and Carlquist (1998), site condition, genetic pre disposition and environment adaptability could be reasons for the variation found. For Schweingruber (2006), regarding the little known about the influence of climatic factors on wood structure, it is certain that different hydrological and nutritional conditions reduce or enhance growth and modify the size of the water-conducting elements. As an example, in dry environments, the length of vessel elements is usually shorter than in rainy environments (CARLQUIST, 1998).

The presence of septate fibers, with an average length of 887µm, wall thickness of 1,23µm and lumen diameter of 5,7µm was verified, confirming the results found by León (2002) for *Protium aracouchini*, from Venezuela, but occurring in Brazil. However, for Mendes; Paviani (1999) cell wall thickness adapts in accordance with the environment.

Rays present 1 to 3 cells in width and an average height of 206µm. Procumbent, square and upright cells were found throughout the ray (Figure 2). Our average height differs from León's (2002), who found an average of 360µm in *Protium aracouchini*. For Longui et al. (2009), this divergence might be due to seasonal differences, where, for Schewingruber et al. (2006), climatic factors clearly influence the wood anatomical structure. It is important to say that rays with higher height and width are well adapted for water storage, which indicates a better adaptive condition to hydric environmental changes (CARLQUIST, 1998). Having said that, it is worth stating that the studied site is located in the Amazon dry corridor (SOUBIÉS, 1980), a region where the dry season used to be even dryer than other locations in the Amazon. This information helps to understand the divergence found between our results and the one found by León (2002).

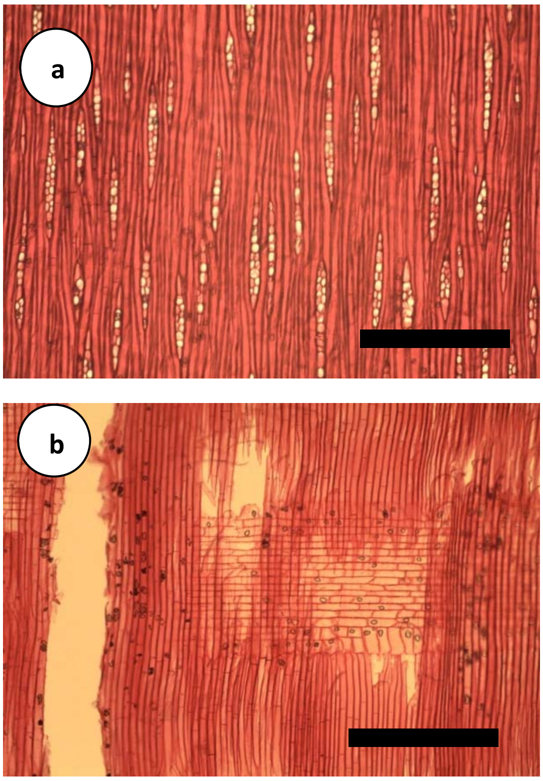

Figura 2. Caracteres anatômicos da *Protium apiculatum.* **a** - Seção tangencial para visualização da altura e tipo de raio; **b** - Células de raio procumbentes com uma linha de células marginais eretas e/ou quadradas. Escala-150μm.
Figure 2. *Protium apiculatum* anatomical characters. **a** - Tangential-section for visualization of ray type and height; **b** - Body ray cells procumbent with one row of upright and/or square marginal cells. Bar-150μm.

Regarding the variation between *Protium apiculatum* trees, significant differences were found between their anatomical elements (Table 1).

According to Pinheiro (1999), this variation might be explained by the internal variability of the material in core-bark direction or at different heights, and by differences between individuals. However, we collected samples from individuals in similar areas and at similar heights. Moutinho et al. (2011) worked with technological properties of different Amazonian species of *Eschweilera* Mart Ex Dc and noticed variation among individuals despite the location; these authors considered the heterogeneity of native forest, such as closeness to clearings, competition, access to water and different genetic materials as reasons for differences between the species.

For fiber length, smaller average values were found in trees 2, 3 and 5, whereas tree 4 presented intermediate average values and tree 1 higher average values. For lumen diameter, smaller average values were found in trees 2 and 4, whereas trees 3 and 5 presented intermediate average values and tree 1 higher average values. Regarding fiber wall thickness, smaller average values were found in trees 2, 3 and 5, with tree 4 presenting intermediate average values and tree 1 higher average values. Although all tree samples were collected in the same area, the differences found can be explained by the local environment, which is classified as Amazon native forest, known by the highly heterogeneous growth conditions existent is this biome.

In this way, Brasil; Ferreira (1972), working in a well-controlled site, found a decreasing variation in bark-pith direction on fiber length and wall thickness in clones of *Eucalyptus grandis*, as well as an increase in fiber diameter in the bark-pith direction. Oliveira et al. (2009), when characterizing *Enterolobium contortisiliquum* in Caatinga and Semi-deciduous forest, obtained significant differences in fiber length, explaining it is due to the environment where the individuals were located.

For vessel length, lower average values in trees 2, 3 and 5 and higher average values in trees 1 and 4 were found. As to vessel tangential diameter, lower average values in trees 1 and 2 and higher average values in trees 3, 4 and 5 were found.

Regarding vessel length, Oliveira et al. (2009) found differences between two biomes where *Enterolobium contortisiliquum* was located, similar to the variations found in our results. However, there were similar values for tangential diameter of vessels in the environments in which they were located. As to the ray height of the studied species, there were smaller average values in trees 1 and 3 and higher average values in trees 2, 4 and 5. According to Lens et al. (2004), the environmental differences of the site can influence ray height. In this case, it is important to say that the studied trees came from native forest, which means a high genetic variability. Furthermore, the forest in this case was harvested 30 years ago, aiming to evaluate the impacts on the vegetation, as well as the forest recomposition. Thus, competition between the trees, sun incidence and water access, among other factors, were very different for each tree, which corroborates the species variability found in this work.

Tabela 1. Dados quantitativos e comparação entre médias.
Table 1. Quantitative data and comparison between means.

Quantitative anatomical characteristics	Tree 1*	Tree 2*	Tree 3*	Tree 4*	Tree 5*
Fiber length	998 (1229±753) c	827 (1237±634) a	833 (1023±635) a	944 (1141±770) b	832 (984±634) a
Lumen diameter	6,3 (9,4±4,5) c	5,2 (8,2±2,9) a	5,8 (10,1±3,1) b	5,5 (9,5±3,1) a	5,8 (7,3±4,5) b
Fiber wall thickness	1,14 (16,62±0,67) a	1,11 (1,51±0,84) a	1,35 (1,79±0,95) c	1,30 (2,05±0,97) c	1,25 (1,80±0,88) b
Vessel length	330 (613±129) b	271 (404±186) a	277 (459±136) a	318 (750±170) b	257 (384±132) a
Vessel tangential diameter	91 (168±45) a	101 (134±54) a	120 (162±68) b	111 (173±49) b	113 (140±71) b
Ray heigth	199 (312±112) a	213 (408±109) b	190 (359±103) a	219 (437±129) b	210 (329±119) b

*Values are in micrometers. Values in the same row followed by the same letters are not statistically different from each other according to Scott and Knott test at 5% significance level.

Conclusions

The anatomical characters observed in *Protium apiculatum* Swart resemble the other species of its genus, but a significant variability between the studied trees was found, which can be explained by the heterogeneous site conditions and the genetic variability.

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