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Wood chemical characterization of *Acacia mangium* and *Calophyllum brasiliense* grown in plantation

Caracterização química das madeiras de *Acacia mangium* e *Calophyllum brasiliense* em plantio

Caracterización química de la madera de *Acacia mangium* y *Calophyllum brasiliense* en plantación

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Abstract
This study aimed to characterize and compare the physical and chemical properties of wood from 15-year-old *Acacia mangium* and 16-year-*old Calophyllum brasiliense* plantation trees. Specific data is provided on basic density, extractives, holocellulose, lignin, ash content and the highest heating value, as well as the linear correlations between them were performed. We observed similar mean values of basic density, despite statistical differences were found in lignin and holocellulose contents. The results for the higher heating value (19.5 kJ kg^{-1}) were noteworthy, as they are positively associated with the extractive content (8.3%) and lignin content (26.0%) of *A. mangium* and *C. brasiliense*, respectively. Furthermore, the relationships found between the basic density of *C. brasiliense* wood, and its chemical properties were different from those expected, suggesting that other analyses should be carried out on the wood in order to fully understand it. Both species demonstrate calorific values suitable for biomass production, suggesting the potential use of their residues for pellet and briquette manufacturing. The findings have provided valuable information on the quality and behavior of wood, especially to contribute to the sustainable use of forest resources.
Keywords: Extractives; Lignin; Holocellulose; Ash; Higher heating value.

Resumo
Este estudo teve como objetivo caracterizar e comparar as propriedades físicas e químicas da madeira de plantações de *Acacia mangium*, com 15 anos, e *Calophyllum brasiliense*, com 16 anos. Dados específicos são fornecidos sobre densidade básica, extrativos, holocelulose, lignina, teor de cinzas e poder calorífico superior, bem como as correlações lineares entre as propriedades. Observamos valores médios semelhantes de densidade básica, apesar de diferenças

estatísticas terem sido encontradas nos teores de lignina e holocelulose. Os resultados para o poder calorífico superior (19,5 kJ kg^{-1}) foram dignos de nota, pois estão positivamente associados ao teor de extrativos (8,3%) e teor de lignina (26,0%) de *A. mangium* e *C. brasiliense*, respectivamente. Além disso, as relações encontradas entre a densidade básica da madeira de *C. brasiliense* e suas propriedades químicas foram diferentes das esperadas, sugerindo que outras análises devem ser realizadas na madeira para compreendê-la completamente. Ambas as espécies demonstram valores caloríficos adequados para produção de biomassa, sugerindo o uso potencial de seus resíduos para fabricação de pellets e briquetes. As descobertas forneceram informações valiosas sobre a qualidade e o comportamento da madeira, especialmente para contribuir com o uso sustentável dos recursos florestais.
Palavras-chave: Extrativos; Lignina; Holocelulose; Cinzas; Poder calorífico superior.

Resumen

Este estudio tuvo como objetivo caracterizar y comparar las propiedades físicas y químicas de la madera de plantaciones de *Acacia mangium* de 15 años y *Calophyllum brasiliense* de 16 años. Se proporcionan datos específicos sobre densidad básica, extractivos, holocelulosa, lignina, contenido de cenizas y poder calorífico superior, así como correlaciones lineales entre propiedades. Observamos valores medios similares de densidad básica, aunque se encontraron diferencias estadísticas en los contenidos de lignina y holocelulosa. Destacaron los resultados para el mayor poder calorífico (19,5 kJ kg^{-1}), ya que se asocian positivamente con el contenido de extractivos (8,3%) y de lignina (26,0%) de *A. mangium* y *C. brasiliense*, respectivamente. Además, las relaciones encontradas entre la densidad básica de la madera de *C. brasiliense* y sus propiedades químicas fueron diferentes de las esperadas, lo que sugiere que se deben realizar más análisis en la madera para comprenderla completamente. Ambas especies demuestran valores caloríficos adecuados para la producción de biomasa, lo que sugiere el potencial uso de sus residuos para la fabricación de pellets y briquetas. Los hallazgos proporcionaron información valiosa sobre la calidad y el comportamiento de la madera, especialmente para contribuir al uso sostenible de los recursos forestales.
Palabras clave: Extractivos; Lignina; Holocelulosa; Ceniza; Poder calorífico superior.

1. Introduction

The wood is derivative from vascular cambium, it is mainly comprised with dead cells with thickened cell walls rich in cellulose, hemicelluloses, and lignin and responsible for providing mechanical support and conducting water and minerals for the plants (Mauseth, 2016). The major carbohydrate portion of wood, the cellulose is the most abundant organic chemical on the earth. Lignins are amorphous, highly complex, mainly aromatic polymers of phenylpropane units that are considered to be an encrusting substance. Extractives are chemicals in the wood that can be extracted using solvents (Rowell, 2012). Ash content consists of inorganic elements that remain after complete combustion of the wood such as calcium, potassium and magnesium to other components (Costa et al., 2017). Also, into physical properties, the wood density is considered one of the most informative properties, and it is influenced by anatomical characteristics (Wiedenhoeft and Eberhardt, 2021), silvicultural and climate conditions.

Studying the basic density and chemical characteristics of wood is essential to know the values of these properties, both for a broader understanding of how plants are affected by climate change, and how external properties interact in the adaptation of plants to their environments, as well as in various areas of industry in order to define their potential applications. Recent studies also explored the chemical elements of wood to identify limits of annual growth rings in conifers, and tropical tree species, respectively (Hevia et al., 2018; Rodriguez et al., 2022).

In industry, we can cite some examples of how wood chemicals are essential to know, e.g., a higher content of extractives may contribute less wood specific gravity, which affects mechanical properties (Senalik and Farber, 2021). Lignin content influences the brightness of cellulosic pulp. It is, therefore, an important variable in the manufacturing process (Kiaei et al., 2014). Recent studies have shown new applications for cellulose as materials molded with wood cellulose fibers how alternatives to petroleum-based glass fiber/polymer composites (Yang, 2019). For bioenergy purposes, ash content reduces the higher heating value, which is the absolute value of specific energy (Telmo and Lousada, 2011), affecting its performance as solid fuel wood (Silva, 2018).

The major carbohydrate portion of wood is composed of cellulose and hemicellulose, cellulose is the most abundant organic chemical on the earth. Lignins are amorphous, highly complex, mainly aromatic polymers of phenylpropane units that are considered to be an encrusting substance. Extractives are chemicals in the wood that can be extracted using solvents (Rowell, 2012). Ash content consists of inorganic substances that remain after complete combustion of the wood (Costa et al., 2017). Higher heating value is the absolute value of specific energy (Telmo & Lousada, 2011).

Many commercial woods remain understudied with unknown potential uses. This calls for a comprehensive study of all wood characteristics, including their chemical characteristics. Thus, the basic density and the essential chemicals (extractives, lignin, holocellulose, and ash, as well as higher heating value) of *Acacia mangium* and *Calophyllum brasiliense* wood were studied at 15 and 16 years, respectively. It is anticipated that the data revealed in this study will be of interest to scientific researchers and timber specialists alike. Therefore, this study aimed to characterize and compare the physical and chemical properties of wood from *Acacia mangium* (15 years old) and *Calophyllum brasiliense* (16 years old) plantations, located in Pindamonhangaba, São Paulo, Brazil.

2. Methodology

2.1 Study area

The raw material of this study, *Acacia mangium* Willd. Fabaceae (acácia) and *Calophyllum brasiliense* Cambess. Calophyllaceae (guanandi), was kindly provided from harvested crops cultivated from Reflorestadora Cicero Prado & Guanandi-CP4 Instituto Coruputuba in Pindamonhangaba, SP, Brazil. Commercial plantations of both species are situated at 22°54'31"S 45°23'11"W (elev. 560m) (Figure 1). According to the Köppen climate classification, the climate of Pindamonhangaba municipality can be classified as Cwa (humid subtropical with dry winter and hot summer). Meteorological data indicate an average annual air temperature of 18.9°C and average annual precipitation of 1,590.8 mm with almost 81% occurring between October and March (Alvares et al., 2013). The climatological water balance allows for an understanding of the water regime of the region where the area is located (Figure 1). From October to April, water supply exceeds 728.1 mm, whereas the soil water deficit, which is 3.5 mm per year, extends from June to August, peaking in July. Planting for both species (Figure 2) was established at a spacing of 3 m x 2 m without fertilization. The plantings were installed in Melanic Gleisol, or, more specifically, the association of dystrophic Tb Melanic Gleisol, clayey texture + Tb Fluvic Neosol, medium texture + Organosol, both flat relief phase (Rossi, 2017).

2.2 Sampling

We determined height, DBH (diameter at breast height - 1.30 m from the ground) in 12 trees of each species, totaling 24 trees. The average DBH and tree height were (24 cm and 22 m) in *Acacia mangium* and (16.5 cm and 13 m) in *Calophyllum brasiliense*, respectively, according to the methodological recommendations of Pereira et al. (2018). The selected trees were felled, and from each tree, a 1-meter-long log was cut from the region immediately below breast height, following Lima et al. (2024). From the logs, a central plank (5 cm thick) was cut. From these planks, battens (4 cm × 4 cm) were cut from the heartwood using a tenon saw to prepare specimens (5 cm × 3 cm × 2 cm) for determining the basic density of the wood and analyzing its chemical properties, following the Brazilian standard ABNT NBR 7190-3 (ABNT, 2022) (Figure 3).

2.3 Basic density

Basic density was determined by finding the ratio between dry mass and saturated volume. The specimens (5 cm × 3 cm × 2 cm) were immersed in water and were considered saturated when they presented constant mass during monitoring in the

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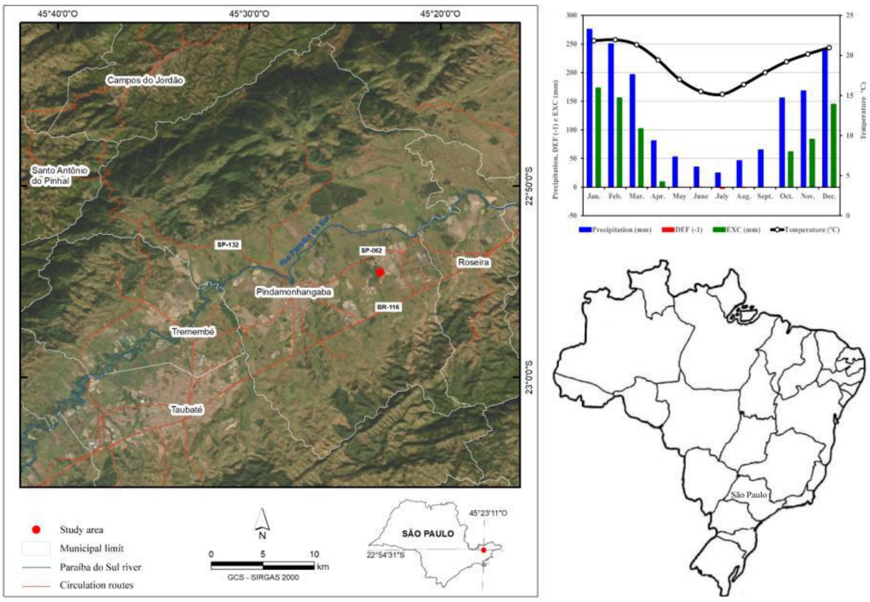
laboratory. Subsequently, the specimens were dried in an oven at 105°C ± 2°C to obtain the dry mass. Saturation volume was obtained by the hydrostatic balance method. Wood basic density was calculated by determining the relationship between dry mass and saturated volume in accordance with the Brazilian standard ABNT NBR 7190-3 (ABNT, 2022).

Figure 1 - Location in municipality of Pindamonhangaba (red circle) in São Paulo State, Brazil. Average monthly sum of precipitation, water deficit DEF (-1), water surplus (EXC), and mean temperature (line).

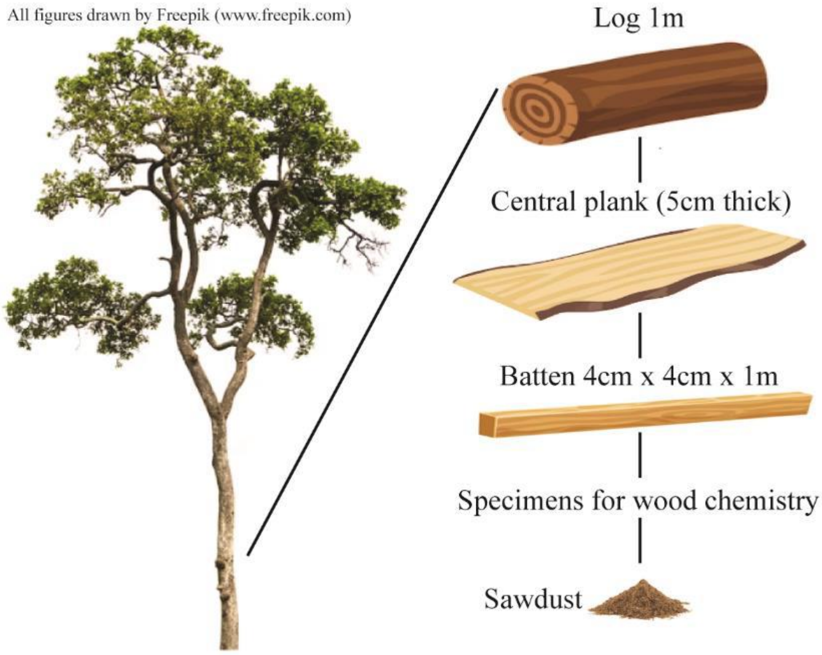


Source: Authors.

Figure 2 - Overview of *Acacia mangium* and *Calophyllum brasiliense* plantations in the municipality of Pindamonhangaba, São Paulo State.

Source: Authors.

Figure 3 - Schematic illustration of sampling for wood density and chemistry.



Source: Authors.

2.4 Chemical characterization

For wood chemistry samples, pieces were cut into chips. Wood chip samples from both species, 24 samples were fragmented into smaller pieces with a hammer and chisel, milled in a metallic steel-type Wiley knife mill, and transformed into sawdust. The resulting powder was sieved through 40 and 60 mesh screens, and the material retained on the last sieve was used for chemical analyses. Triplicates were performed for each sample to guarantee more accurate results. Standards and procedures are presented in Table 1.

Table 1 - Variables determined in chemical analyses and related standard/procedure.

Variable	Standard/procedure	References
Sampling and preparing wood for analyses	TAPPI Standard – T 257 cm-85	Tappi (1985)
Extractives content (EC)	TAPPI Standard - T 204 om-97	Tappi (2004)
Lignin content (LC)	TAPPI Standard - T 222 om-02	Tappi (2002)
Ash content (AC)	TAPPI Standard – T 211 om-91	Tappi (1991)
Higher heating value (HHV)	ASTM - D5865-98	ASTM (1998)

Source: Authors.

2.5 Extractives, lignin and holocellulose

Analyses were sequential. Extractives (EC) were first removed, followed by calculation of lignin (LC) and holocellulose (HC) content. For extractive contents, solutions of toluene: alcohol (2:1 v:v) and alcohol extractions were employed, at times exceeding 12 h in a Soxhlet extractor. For lignin, extractive-free powder was prepared in several stages with 72% sulfuric acid to obtain insoluble and soluble lignin (Cary 100 UV–visible spectrophotometer). Finally, the two values

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of lignin were added. Ex and Li were expressed as a percentage (%) of oven-dry weight of unextracted wood. Then, the holocellulose (Ho) content was determined as
HC = [100−(Ex+Li)].

2.6 Ash

Samples were weighed in crucibles previously calcined at 575°C for 30 minutes. Then, they were placed in a muffle furnace (model 0212) for 6 hours at 600°C. After the predetermined treatment time, the crucibles containing ashes were cooled in a desiccator for 30 minutes and weighed on an analytical scale (Shimadzu, model AUY220). Ash content was determined as Ash content = A x 100/B, where A = weight of ash (g), and B = weight of test specimen (g, moisture-free).

2.7 Higher heating value

Samples were fragmented into smaller pieces with a hammer and chisel and milled in a micro mill. Higher heating value was determined after thermal rectification with dry samples. To perform the analyses, the isoperibolic method was used with an IKA C200 calorimeter.

2.8 Data analysis

We initially undertook descriptive statistical analyses and used Box Plot graphics to detect outliers. Thus, values 1.5 times higher than the 3rd quartile and values 1.5 times lower than the 1st quartile were excluded from the analyses. Normality tests were performed to check the distribution of data, and when a normal distribution was not observed, data were square root-transformed. Then, the t test was used to identify pairs of significantly different means. Pearson's correlation test was applied to basic density and chemical properties. Statistical analyses were performed using R software and SigmaPlot 14.5 (R Core Team, 2019; SigmaPlot, 2023).

3. Results and Discussion

We present the means for each variable in each tree and the means of the 12 trees in both species (Table 2). In the comparison between chemical characteristics, we observed significant differences, but only for lignin and holocellulose contents (Figure 4).

As they result from the same sequential methodology, in which their percentages are determined, we understand that it is not correct to analyze the correlations between extractives, lignin, holocellulose and ash. Thus, the valid correlations are those of basic density, higher heating value and those described in the sequential methodology. The correlation values used in the present study are (0.01 – 0.20 very weak), (0.21 – 0.40 weak), (0.41 – 0.60 moderate), (0.61 – 0.80 strong) and (0.81 – 0.99 very strong) (Lopes, 2016).

For *Acacia mangium*, we highlight a weak negative correlation between ρbas and HC (-0.22); Weak positive correlations between HHV and EC (0.27) and strong between HHV and AC (0.62), and weak negative correlation between HHV and HC (-0.33). For *Calophyllum brasiliense* there are moderate negative correlations between □bas and AC (-0.59) and between HHV and ρbas (-0.49); and weak negative correlation between HHV and EC (-0.33), moderate positive correlation between HHV and LC (0.57), weak negative correlation between HHV and HC (-0.22), and weak positive correlation between HHV and AC (0.28) (Figure 5).

Table 2 - Chemical characteristics of *Acacia mangium* and *Calophyllum brasiliense* wood at 15 and 16 years, respectively.

Species	Tree	□bas (kg m^{-3})	EC (%)	LC (%)	HC (%)	AC (%)	HHV (kJ kg^{-1})
A. mangium	1	515	9.74	24.60	65.66	0.32	19328
	2	470	9.05	20.95	70.00	0.62	19819
	3	543	4.94	26.35	68.71	0.81	19652
	4	614	9.05	22.94	68.01	0.63	19618
	5	600	8.62	25.47	65.91	0.73	19995
	6	453	11.61	24.36	64.03	0.39	19842
	7	515	4.13	25.78	70.09	0.44	19661
	8	476	8.15	21.21	70.65	0.80	19676
	9	515	4.44	23.60	71.96	0.16	19351
	10	561	11.44	22.31	66.25	0.33	19544
	11	508	7.45	22.69	69.86	0.29	19418
	12	634	11.19	21.59	67.22	0.40	19739
	Mean	534	8.32	23.49	68.19	0.49	19637
C. brasiliense	1	484	3.28	28.96	67.76	0.72	19764
	2	613	7.52	25.46	67.03	0.44	19164
	3	562	8.69	26.67	64.65	0.44	19568
	4	544	8.31	26.96	64.74	0.46	19685
	5	535	7.87	28.00	64.13	0.32	19598
	6	458	10.26	24.38	65.36	0.64	19688
	7	541	10.75	22.19	67.07	0.42	19245
	8	515	10.67	23.20	66.13	0.79	19416
	9	547	6.41	27.15	66.44	0.50	19477
	10	548	7.79	26.10	66.12	0.56	19389
	11	544	7.66	27.16	65.17	0.64	19953
	12	562	4.57	25.42	70.01	0.37	19605
	Mean	538.35	7.81	25.97	66.22	0.53	19546

(□bas) extractives content (EC), lignin content (LC), holocellulose content (HC), ash content (AC) and higher heating value (HHV).
Source: Authors.

The physical and some chemical wood characteristics of *Acacia mangium* and *Calophyllum brasiliense* were compared, providing specific data on basic density, extractives, holocellulose, lignin, ash content, and higher heating value, which are essential to both scientific researchers and specialists in the timber industry. In comparative terms, the woods only showed differences in the lignin and holocellulose contents. The correlations between the variables were different between the two species.

We highlight in general the uses of wood from both species to get an idea of how they can relate to the results of our study. For *A. mangium*, suggestions of uses were found in civil construction, furniture, crafts, cellulose pulp, plywood and chipboard, among others, and can be characterized as a multiple-use species (Arco-Verde, 2002).

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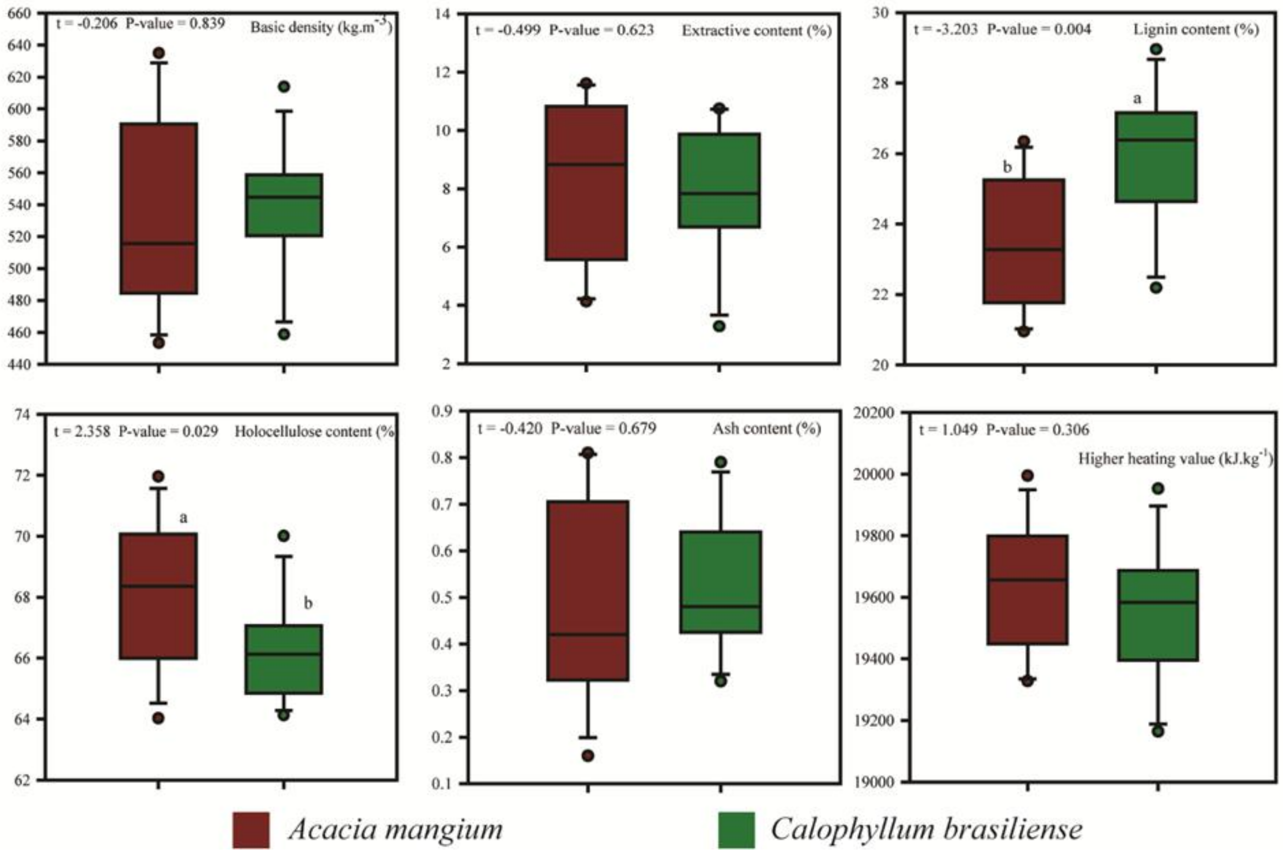
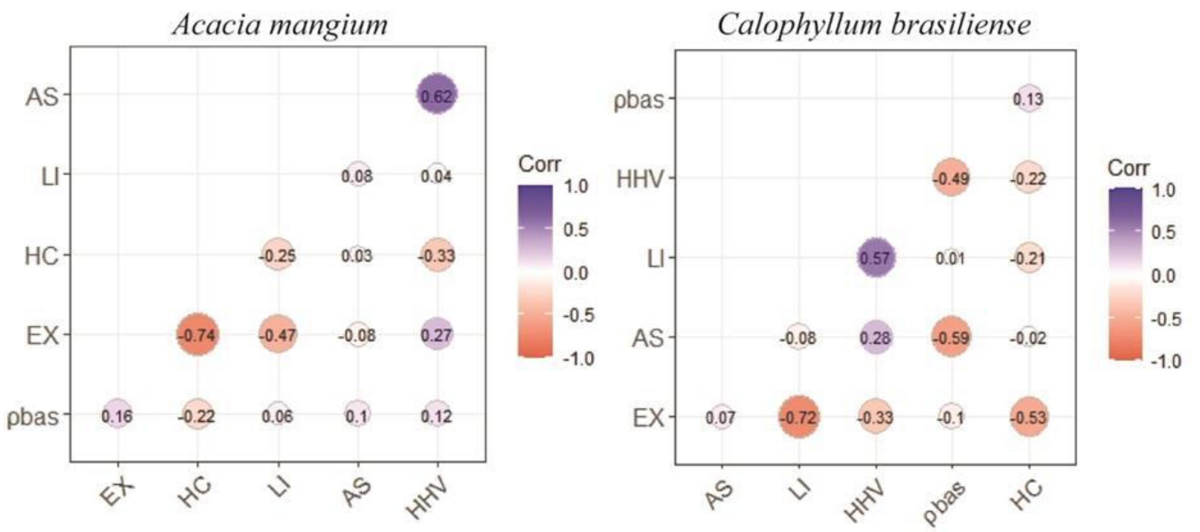
Figure 4 - Comparison between basic density and chemical properties of *Acacia mangium* and *Calophyllum brasiliense* wood at 15 and 16 years, respectively. Different letters (a or b) indicate statistical significance by t-test (p<0.05).



Source: Authors.

Figure 5 - Pearson's Correlation Coefficient between basic density and chemical properties of *Acacia mangium* and *Calophyllum brasiliense* wood at 15 and 16 years, respectively. basic density (ρbas) extractives content (EC), lignin content (LC), holocellulose content (HC), ash content (AC) and higher heating value (HHV).



Source: Authors.

In the case of *C. brasiliense*, it is used in the form of sawn and round wood in several applications (Carvalho, 2003). For energy, it features wood with a moderately low lignin content and regular quality charcoal; good wood for paper production (Paula 1982), also can be characterized as a multiple-use species. Even so, the *C. brasiliense* wood is still little used in Brazil, in contrast to its popularity in other countries in South America and the Caribbean and can replace *Swietenia* spp. and *Cedrela* spp. aesthetically (Carvalho, 2003).

The average basic density of *A. mangium* and *C. brasiliense* was 534 ($kg.m^{-3}$) and 538 ($kg.m^{-3}$), respectively, values considered medium for both species (Andrade and Jankowsky, 2015). In seven-year-old trees of *A. mangium* grown in Indonesia, values of 460 $kg.m^{-3}$ for wood density, were reported (Yahya et al., 2010). For *C. brasiliense* wood, studies report a basic density of 490 to 510 $kg.cm^{-3}$ (Arostegui, 1982; Jankowsky et al., 1990). The differences in values with those in our study are possibly related to different ages of the trees and edaphoclimatic conditions, as well as variations within the species itself or sampling within the tree. In any case, determining the basic density is key in any study on wood quality, as it is an easily accessible property that is well related to explaining other properties of wood.

Extractives are formed by parenchyma cells at the heartwood-sapwood boundary and are then exuded through pits into adjacent cells (Hillis, 1996) and are responsible for the different colors in wood (Rowell, 2012). It is essential to study color variations to provide information for the best use of the wood, and the optimization of the performance of the pieces in the sawmill through the aesthetic form most acceptable to the end consumer. It was identified that color parameters from *A. mangium* wood are more strongly influenced by anatomical section than radial position in the trunk (Gomes et al., 2021). The heartwood of *A. mangium* wood is light brown, with darker bands (Arco-Verde, 2002). The heartwood of *C. brasiliense* varies from pinkish brown to pinkish beige, tending towards brown (Carvalho, 2003). To repeat, when compared with the results of other studies, the differences in wood chemistry could be explained by differences in collection sites, soil composition or tree age, which might influence heartwood formation and extractives percentage.

When comparing the chemical constituent content, we observed variations in lignin content (higher in *C. brasiliense*) and holocellulose content (higher in *A. mangium*). In general, the wood quality destined for the energy sector is directly related to its composition (Santos et al., 2021). Woods most suitable for bioenergy are those with lower holocellulose and ash contents, and higher lignin values and consequently higher calorific value (Couto et al., 2004, Pereira et al., 2012). In the paper and cellulose industry, low levels of extractives and lignin and high levels of holocellulose are desirable in wood (Morais et al., 2010).

A study with *C. brasiliense* from a tree in the municipality of Cuiabá, state of Mato Grosso reported lignin levels with extractives (31.38%), holocellulose (67.34) and ash (1.28) (Carli et al., 2012). Values slightly different from ours for lignin with extractives (33.78%) and holocellulose (66.22), only the ash content (0.53) was higher than in the present study. In another study, lignin content (28%) was reported in *A. mangium* planting (Pinto et al., 2005), above the value in our study (23.49%).

In seven-year-old trees of *A. mangium* grown in Indonesia, values of 460 kg.m-3 for wood density, 80.43% and 31.30% for holocellulose and lignin contents, respectively, were reported (Yahya et al., 2010). In our study, the average density was higher and holocellulose and lignin content were lower, which is possibly related to age, as the trees in our study were 15-year-old, and to climate and soil factors. Extractives and ashes content may vary due edaphoclimatic factor (Zau et al., 2014). In our study, the trees grew in the same environment, therefore, it is understood that the lack of variation in these two variables between species is due more to genetic factors.

In our study, both species presented low ash contents, an essential result, since low values are associated with less need to remove these residues from the burning system, contributing to the generation of clean and sustainable energy. The higher the ash content, the lower the energy potential of a given wood (Dias Júnior et al., 2021). Ashes and extractives content may vary due edaphoclimatic factor (Zau et al., 2014). The physicochemical properties and composition of the ash indicate that *Acacia mangium* wood pellets can be classified as suitable as solid woody biofuel (Duong et al., 2022).

Woods with basic density above 520 $kg.cm^{-3}$ are recommended for energy purposes (Carvalho et al., 2014). In the present study, both species has values above this criterion. It is reported that wood with a high proportion of fibers (from 60%) with thick walls, has good quality for energy generation, on the other hand, wood with a high proportion of vessels and parenchyma cells has lower energy potential, due to the low content of cellulose, lignin and hemicelluloses, which means little biomass to support long-lasting combustion (Paula, 2005).

Acacia species, including *A. mangium* are a sustainable source of high-quality biomass feedstock for bioenergy production in Brunei, being important to the country's economy, providing new investment and employment opportunities (Ahmed et al., 2018). Values of 28657 ($kJ.kg^{-1}$) and 0.1% for calorific power and ash, respectively, were reported for the energetic characteristics of *C. brasiliense* charcoal (Nisgoski et al., 2014). Highlighting that the values measured from wood and charcoal may vary. In any case, we cite Nisgoski's study, as literature on wood chemistry in *C. brasiliense* is scarce.

In Brazil, we understand that both species studied should be used for nobler purposes than biomass, due to the country's ability to produce biomass from other wood sources such as *Eucalyptus* spp. However, the results found here show that residues from both woods can be used as bioenergy, as they have adequate values. It should be noted that the use of native Brazilian wood for energy purposes is only viable, from an economic and ecological point of view, if included in the formation of large heterogeneous forest masses under ecological management plans with sustainable yield, in order to avoid excessive extractivism scale for energy purposes (Paula, 2005). As an example, *Dipteryx odorata* wood is cited, which is a noble wood and widely used in the wood industry. However, throughout the processing of wood, 60% of waste is generated, which ends up being reused to generate electricity energy through burning (Zau et al., 2014).

As for correlations, for *A. mangium*, we highlight a weak negative correlation between ρbas and HC, a positive correlation would be more expected, since holocellulose makes up the largest percentage of the wood, and, therefore, would have a positive influence on density. Positive and significant correlation between the basic density of *Eucalyptus* wood and holocellulose content, suggesting that denser wood has lower lignin content; due to present relatively young wood, the holocellulose and lignin contents have not yet reached stability (Trugilho et al., 1996). Our results demonstrate weak positive correlations between HHV and EC, weak negative correlation between HHV and HC. It is known that the calorific value will be higher the higher the lignin and extractive contents, as these contain less oxygen when compared to the polysaccharides present in holocellulose (Browning, 1963). Like our study, wood basic density was negatively correlated with ash content in Eucalyptus hybrids (Soares et al., 2014). We reported strong positive correlations between HHV and AC. It is noteworthy that high ash contents negatively interfere with HHV, as the ash (mineral compounds) does not undergo combustion (Brand, 2010).

For *Calophyllum brasiliense* there are moderate negative correlations between ρbas and AC. In general, a positive correlation is expected, since the greater the density of the wood, obviously, the greater the amount of dry matter per unit volume (Brito and Barrichelo, 1977). However, it is known that ash values vary and sometimes the ρbas x AC correlation is not easily explained. Likewise, it was surprising to find a negative correlation between HHV and ρbas, since it is expected that the greater the mass, the greater its burning potential. Basic density positively influences energy density. The greater the mass per volume, the greater the thermal energy released during burning (Santos et al., 2023). In *A. mangium*, there is a weak positive correlation between HHV and EC, already at *C. brasiliense*, a weak negative correlation between HHV and EC, moderate positive correlation between HHV and LC, weak negative correlation between HHV and HC. Here, we again refer to the study by Browning (1963) cited above, to explain such correlations. Additionally, a weak positive correlation between HHV and AC was expected.

4. Conclusion

In comparative terms, the woods only showed differences in the lignin and holocellulose contents. This shows that even though *Acacia mangium* (Fabaceae) and *Calophyllum brasiliense* (Calophyllaceae) are distinct families, there is a certain homogeneity between chemicals content investigated here. However, more detailed studies of wood chemicals should find peculiarities, which should guide the industrial uses of each component.

The correlations showed for *Acacia mangium*, a weak negative correlation between ρbas and HC, weak positive correlations between HHV and EC, strong between HHV and AC, and weak negative correlation between HHV and HC. For *Calophyllum brasiliense* there are moderate negative correlations between ρbas and AC and between HHV and ρbas; and weak negative correlation between HHV and EC, moderate positive correlation between HHV and LC, weak negative correlation between HHV and HC, and weak positive correlation between HHV and AC. These correlations demonstrate the influence of wood's basic density on various chemical properties, and in turn density is chemical constituents on higher calorific value, providing important insights into the quality and behavior of wood.

Finally, both wood presented calorific values within the range acceptable to produce biomass. Instead of raw wood, its residues can be used for such purposes as producing pellets and briquettes.

The values obtained for the chemical properties of *Acacia mangium* (15 years old) and *Calophyllum brasiliense* (16 years old) wood can be used for comparative purposes with species currently employed in the timber industry in Brazil. Further studies are recommended to explore and expand the potential applications of these species.

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