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Chemical characterization of eleven Latin America woods

Caracterização química de onze madeiras da América Latina

Caracterización química de once maderas de América Latina

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Abstract

The forests of Latin America are home to diverse species of interest regarding the chemical constituents of wood. This calls for a comprehensive study of all wood characteristics, including their chemical characteristics. This article aimed to characterize the essential chemicals of 11 Latin American native forest species. From wood samples of trees more than 20 years of age, we determined the contents of total extractives, total lignin, holocellulose, and ash, as well as higher heating value. The usual standards were applied in each analysis. Analysis of variance and the Bonferroni test were used to determine differences among variables in each species. In all characteristics, the results varied among the different species. When compared with the results of other studies, we found that the differences in wood chemistry could be explained by differences in collection sites, soil composition or tree age. The main contribution and novelty of this study lies in disseminating to a wide number of professionals the variations found in the chemical constituents of the wood studied. Therefore, it is anticipated that the data revealed in this study will be of interest to scientific researchers and timber specialists alike.

Keywords: Extractives; Lignin; Holocellulose; Ash; Higher heating value.

Resumo
As florestas da América Latina abrigam diversas espécies de interesse em relação aos constituintes químicos da madeira. Isso exige um estudo abrangente de todas as características da madeira, incluindo suas características químicas. Este artigo teve como objetivo caracterizar os compostos químicos essenciais de 11 espécies florestais nativas da América Latina. A partir de amostras de madeira de árvores com mais de 20 anos de idade, determinamos os teores de extrativos totais, lignina total, holocelulose e cinzas, bem como o poder calorífico superior. Os padrões usuais foram aplicados em cada análise. A análise de variância e o teste de Bonferroni foram utilizados para determinar as diferenças entre as variáveis em cada espécie. Em todas as características, os resultados variaram entre as diferentes espécies. Quando comparados com os resultados de outros estudos, descobrimos que as diferenças na química da madeira podem ser explicadas por diferenças nos locais de coleta, composição do solo ou idade da árvore. A principal contribuição e novidade deste estudo reside na disseminação para um amplo número de profissionais das variações encontradas nos constituintes químicos das madeiras estudadas. Portanto, espera-se que os dados revelados neste estudo sejam de interesse tanto para pesquisadores científicos quanto para especialistas em madeira.
Palavras chaves: Extrativos; Lignina; Holocelulose; Cinzas; Poder calorífico superior.

Resumen
Los bosques latinoamericanos albergan una variedad de especies de interés en cuanto a los componentes químicos de la madera. Esto requiere un estudio exhaustivo de todas sus características, incluyendo sus propiedades químicas. Este artículo tuvo como objetivo caracterizar los compuestos químicos esenciales de 11 especies forestales nativas de América Latina. Utilizando muestras de madera de árboles mayores de 20 años, determinamos el contenido de extractivos totales, lignina total, holocelulosa y cenizas, así como el valor calorífico bruto. Se aplicaron estándares estándar a cada análisis. Se utilizaron análisis de varianza y la prueba de Bonferroni para determinar las diferencias entre las variables dentro de cada especie. Para todas las características, los resultados variaron entre las diferentes especies. Al comparar los resultados de otros estudios, observamos que las diferencias en la química de la madera pueden explicarse por diferencias en los sitios de recolección, la composición del suelo o la edad de los árboles. La principal contribución y novedad de este estudio radica en la difusión de las variaciones encontradas en los componentes químicos de las maderas estudiadas a un amplio espectro de profesionales. Por lo tanto, se espera que los datos revelados en este estudio sean de interés tanto para investigadores científicos como para expertos en madera.
Palabras clave: Extractivos; Lignina; Holocelulosa; Ceniza; Poder calorífico superior.

1. Introduction

Wood chemistry analysis involves isolation, purification, and characterization of wood constituents (Hon and Shiraishi, 2000). Wood is a heterogeneous material consisting of different types of cells and tissues, all having specific characteristics and physicochemical properties important to the performance of vital plant functions (Botosso, 2009; Fonte et al., 2017). Chemical properties are related to the macromolecular components that constitute the cell wall, such as cellulose, hemicelluloses, and lignin, as well as the incidental components of low molecular weight, including ash and extractives, which vary according to wood species (Klock et al., 2005), in turn influencing selection for industrial uses Fonte et al. (2017).

The biochemicals of heartwood remain functional, even after long-term storage, depending on species. These biochemicals are known collectively as extractives (Wiedenhoeft and Eberhardt, 2021). Extractives are compounds with a low degree of polymerization, or nonpolymerization, and they are not an essential part of wood structure. Extractives are, moreover, substances soluble in neutral organic solvents (alcohol, benzene, toluene, ether, and others), soluble in water, or substances that can be dragged by water vapor (Silva, 2018).

The main carbohydrate portion of wood is composed of cellulose and hemicellulose polymers with small amounts of other polymers. The combination of cellulose (40-45 %) and hemicelluloses (15-25 %) is called holocellulose, and it generally accounts for 65 % to 70 % of the dry weight of wood (Rowell, 2013). Lignins, on the other hand, are extremely complex amorphous polymers of phenylpropane units that are considered an encrusting substance, increasing cell support (Evert and Esau, 2013). Lignins mainly consist of three basic building blocks: guaiacyl, syringyl and p-hydroxyphenyl. In angiosperms, lignin content in wood is generally in the range of 18 to 25 % (Rowell, 2013).

Ash content consists of inorganic substances that remain after complete combustion of the wood (Costa et al., 2017). Such substances range from calcium, potassium and magnesium to other components present in lower amounts, but they can all directly influence the calorific value and performance of coal as a bioenergy source (Silva, 2018).

Biomass is an interesting energy source, primarily because it can contribute to sustainable development (van den Broek et al. 2000). However, the most important parameter is calorific value, which can be defined as the number of units of energy produced by the combustion of a unit mass of fuel. The calorific value of wood can be expressed as follows: higher heating value at constant volume (dry basis), low heating value at constant pressure (dry basis), and low heating value at constant pressure (wet basis or as received). Higher heating value is the absolute value of specific energy (Telmo and Lousada, 2011).

Wood is one the world´s most important renewable raw materials. Wood-based products are used in new markets in wood construction, in the chemical industry and in textiles (Hurmekoski et al., 2019). However, most wood products that could be suitable for the bioeconomy market are still in the early stages of development. Among these early-stage products are wood foam, glycols, bioplastics (both from tall oil and wood sugars), lignin-based adhesives and wood-based composites, all of which are poised to enter the market in the next 20 years (Hassegawa et al., 2022; Verkerk et al., 2022). The worldwide consumption of sawn wood, veneer, plywood, particleboard, pulp, and other primary wood products is expected to increase by 37 % by 2050, according to a new report published by the Food and Agriculture Organization of the United Nations (FAO, 2024). Latin American countries have an increase demand for wood for various purposes, e.g., charcoal production, pulp and paper, furniture manufacture, and civil construction. These demands can be met by native woods, as long as current laws are observed.

Many Latin American woods remain understudied with unknown potential uses. This calls for a comprehensive study of all wood characteristics, including their chemical characteristics. This article aimed to characterize the essential chemicals (extractives, lignin, holocellulose, and ash, as well as higher heating value) of 11 Latin American native forest species. It is anticipated that the data revealed in this study will be of interest to scientific researchers and timber specialists alike.

2. Methodology

A mixed research was carried out, partly in the field and partly in the laboratory, in a qualitative study in the identification of species and, quantitative in the study of holocellulose, ashes and higher heating values (Pereira et al., 2018) and using simple descriptive statistics with values of relative percentage frequencies (Shitsuka et al., 2014) and statistical analysis (Costa Neto & Bekman, 1993).

2.1 Sampling

Wood samples were taken from the heartwood of trunk at breast height (1.3 m from the ground) of 11 native Latin American species: *Annona crassiflora* Mart. (Annonaceae), *Astronium fraxinifolium* Schott (Anarcadiaceae), *Astronium urundeuva* (M. Allemão) Engl. (Anarcadiaceae), *Balfourodendron riedelianum* (Engl.) Engl. (Rutaceae), *Cariniana legalis* (Mart.) Kuntze (Lecythidaceae), *Genipa americana* L. (Rubiaceae), *Handroanthus vellosoi* (Toledo) Mattos (Bignoniaceae), *Libidibia ferrea* (Mart. ex Tul.) L. P. Queiroz (Fabaceae), *Paubrasilia echinata* (Lam.) Gagnon, H.C.Lima & G.P.Lewis (Fabaceae), *Peltophorum dubium* (Spreng.) Taub. (Fabaceae), and *Terminalia argentea* Mart. & Zucc (Combretaceae). At least five trees (20 – 25 years old) of each species were felled, and discs were cut 15 cm in thickness from each tree at breast height from trees over 30 cm in diameter. Then, pieces of heartwood were selected from the discs and cut into chips. The collection site and their coordinates are shown in Table 1.

Table 1. Species, natural occurrence collection site and coordinates from 11 Latin America woods.

Species	Natural occurrence	Collection site	Latitude	Longitude	Altitude
Annona crassiflora	Brasil, Paraguay.	FEPE	20° 20' S	51° 24' W	335
Astronium fraxinifolium	Argentina, Brasil, Bolivia, Honduras, Paraguay, Venezuela.	FEPE	20° 20' S	51° 24' W	335
Astronium urundeuva	Argentina, Brasil, Bolivia, Paraguay.	FEPE	20° 20' S	51° 24' W	335
Balfourodendron riedelianum	Argentina, Brasil, Paraguay.	EELA	21° 34' S	47° 44' W	550
Cariniana legalis	Brasil.	EELA	21° 34' S	47° 44' W	550
Genipa americana	Argentina, Bolivia, Brasil, Colombia, Costa Rica, Dominica, Ecuador, Guatemala, Guayana Francesa, Guayana, Haití, México, Nicaragua, Paraguay, Perú, Surinam, Trinidad y Tobago, Venezuela.	FEPE	20° 20' S	51° 24' W	335
Handroanthus vellosoi	Brasil.	EELA	21° 34' S	47° 44' W	550
Libidibia ferrea	Brasil.	PEAL	23° 27' S	46° 38' W	863
Paubrasilia echinata	Brasil.	PEAL	23° 27' S	46° 38' W	814
Peltophorum dubium	Argentina, Brasil, Paraguay, Uruguay	PEAL	23° 27' S	46° 38' W	814
Terminalia argentea	Brasil, Bolivia, Paraguay.	FEPE	20° 20' S	51° 24' W	335

FEPE = Fazenda de Ensino, Pesquisa e Extensão - Selvíria-MS; EELA = Estação Experimental de Luiz Antônio - Luiz Antônio-SP; PEAL = Parque Estadual Alberto Löfgren - São Paulo-SP. Source: Authors.

2.2 Preparation for chemical analysis

Wood chip samples from 11 species 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 analysis. Triplicates were performed for each sample to guarantee more accurate results. Standards and procedures are presented in Table 2.

Table 2. Variables determined in chemical analysis and related standard/procedure.

Variable	Standard/procedure	References
Sampling and preparing wood for analysis	TAPPI Standard T257 cm85	Tappi (1985)
Extractives content	TAPPI Standard T204 om97	Tappi (2004)
Lignin content	TAPPI Standard T222 om02	Tappi (2004)
Ash content	TAPPI Standard T211 om91	Tappi (1991)
Higher heating value	ASTM D5865–98	ASTM (1998)

Source: Authors.

2.3 Extractives, lignin and holocellulose

Analyses were sequential. Extractives (Ex) were first removed, followed by calculation of lignin (Li) and holocellulose (Ho) 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 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

Ho = [100 – (Ex + Li)]

2.4 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 B / 100

where A = weight of ash (g), and B = weight of test specimen (g, moisture-free).

2.5 Higher heating value (HHV)

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 analysis, the isoperibolic method was used with an IKA C200 calorimeter.

2.6 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. For radial variation, a parametric one-way analysis of variance (ANOVA) was performed. When a significant difference was observed, Bonferroni's test was used to identify pairs of significantly different means. All statistical analyses were performed using the Sigma Plot software (Exact Graphs and Data Analysis - version 14.5, Systat Software Inc., San Jose, CA, USA (SigmaPlot, 2023).

3. Results and Discussion

This study investigated the chemical characteristics of 11 Latin America woods, providing specific data on extractives, holocellulose, lignin, and ash content, which are essential to both scientific researchers and specialists in the timber industry. When compared with the results of other studies, we found that the differences in wood chemistry could be explained by differences in collection sites, soil composition or tree age. We aimed to show how the results are related to potential industrial uses of the studied woods.

Statistical differences were observed in all variables, according to the Analysis of Variance and the Bonferroni Test (Table 3), and compile the values found by other authors, to simplify the comparison with the values from our study. The dashed lines mean that we did not find studies with the chemical characterization of wood to compare with our results.

Among the 11 species analyzed, the highest levels of extractives were found in *P. echinata* (35.06 %) and the lowest values in *H. vellosoi* (12.36 %), *L. ferrea* (14.61 %), and *A. urundeuva* (14.09 %). The highest percentage of total lignin was found in *T. argentea* (29.45 %) and the lowest in *A. fraxinifolium* (19.40 %). The highest percentage of holocellulose was found in *A. urundeuva* (64.12 %) and the lowest in *P. echinata* (36.22 %). *Cariniana legalis* presented the highest value of ash

(2.02 %), followed by *L. ferrea*, 0.36%; *P. echinata*, 0.35 % and *T. argentea*, 0.65 %. *Paubrasilia echinata* presented the highest value of HHV 19949 $kJ.kg^{-1}$, whereas *A. fraxinifolium* presented the lowest at 18130 $kJ.kg^{-1}$.

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.

Extractives are formed by parenchyma cells at the heartwood-sapwood boundary and are then exuded through pits into adjacent cells (Hillis 1996). Extractives mainly consist of fats, fatty acids, fatty alcohols, phenols, terpenes, steroids, resin acids, rosin, waxes, and many other minor organic compounds (Rowell, 2013).

Extractives are responsible for providing natural durability to timbers that have a resistance to fungal decay; additionally, the color and smell of heartwood depend on the characteristics and concentrations of extractives (Wiedenhoeft and Eberhardt, 2021). Notably, a higher content of extractives may contribute less wood specific gravity, which affects mechanical properties (Senalik and Farber, 2021). Thus, wood with high levels or different types of extractives can be more durable when exposed to rotting fungi. Also, high levels of extractives can contribute to the resistance of wood and, consequently, its selection for certain purposes. In addition to the different colors of extractives, they provide woods that are desirable in terms of aesthetic use. This means that both color and odor given by extractives are essential when selecting wood for the manufacture of furniture (Zenid, 1997). Extractives from certain woods can also be removed and incorporated into different woods to improve some properties, such as stiffness and bending (Minato et al., 1997; Sakai et al., 1999). Studied *Annona crassiflora* wood root and found that ethanol extract has a positive result antimicrobial activity against the fungus Candida albicans in the oral microbiota (Cavalcante et al., 2017). These results support more intensive research into the intrinsic characteristics of wood chemicals.

Impregnation by lignin, a rigid, hydrophobic, and degradation-resistant material, provides protection and diminishes the possibility of cell damage (Alves et al., 2008). Thus, high levels of lignin are desirable if the use requires wood resistance since it reduces the risk of damage to the cell wall and, consequently, damage to the piece of wood. However, if the objective is the production of cellulosic pulp, higher levels of lignin would imply a higher cost of reagents, so woods with lower levels are preferred (Zanuncio and Colodette, 2011). Additionally, lignin content influences the brightness of cellulosic pulp. It is, therefore, an important variable in the manufacturing process (Kiaei et al., 2014). The influence of residual lignin content on the physicomechanical properties of Kraft pulp/pp composites from *Carpinus betulus* wood (Kiaei et al., 2014). The authors report that a decreasing lignin content had a positive impact on flexural and tensile properties, but a negative effect on notched impact strength. This study is interesting in the context of the present work because it is a species outside the Pinus/Eucalyptus axis. *Carpinus betulus* naturally occurs in much of Europe and southwest Asia, and it belongs to the Betulaceae Family (Utad, 2023). Studying *Pinus sylvestris* wood, found no effects of lignin content on the aging rate of paper produced at neutral pH in contrast to common belief (Małachowska et al., 2020). Despite the relative difficulty in obtaining quantities of lignin isolated from wood, lignin has several industrial uses. For example, it can be used as a binder for particleboard and similar laminated or composite wood products, as a soil conditioner, and as a filler or an active ingredient of phenolic resins. Adhesive for linoleum, vanillin (synthetic vanilla) and dimethyl sulfoxide (as bonding agent) is also made from lignin (Britannica, 2023).

Table 3. Wood chemistry analysis from 11 Latin America woods, and compilation of values from other studies (Variable$_{literature}$).

Species	Ex (%)	Ex$_{literature}$ (%)	Li (%)	Ls (%)	Lt (%)	Lt$_{literature}$ (%)	Ho (%)	Ho$_{literature}$ (%)	As (%)	As$_{literature}$ (%)	Hhv (kJ.kg^{-1})	Hhv$_{literature}$ (kJ.kg^{-1})
Annona crassiflora	29.88 b	---	22.85 c	3.29 bc	26.14 cd	---	43.98 d	---	1.56 abc	---	18740 cd	---
Astronium fraxinifolium	20.69 d	4.89[1]	16.40 e	3.00 bc	19.40 f	19.92[1]	59.91 abc	73.65[1]	0.72 de	1.54[1]	18130 f	16791[16]
Astronium urundeuva	14.09 ef	12.75[2]	12.52 d	2.27 bc	21.79 ef	27.13[2]	64.12 a	59.04[2]	0.81 d	1.08[12]	19057 bc	19495[1]
Balfourodendron riedelianum	17.16 e	6.58[3]	20.59 cd	3.56 a	24.15 de	28.36[3]	58.70 bc	65.06[3]	1.18 cd	---	18952 c	19299[17]
Cariniana legalis	18.36 de	9.46[4]	23.15 bc	1.94 bc	25.09 cd	28.43[4]	56.55 c	64.97[4]	2.02 a	0.55[13]	18368 de	18650[13]
Genipa americana	28.58 b	6.99[5]	19.51 d	3.29 bc	22.80 de	27.51[9]	48.62 d	64.07[9]	1.40 bc	0.61[5]	18288 ef	16923[16]
Handroanthus vellosoi	12.36 f	14.35[6]	23.73 bc	2.47 bc	26.19 bc	34.1[7]	61.45 ab	50.56[7]	1.75 ab	0,67[7]	18684 cde	---
Libidibia ferrea	14.61 ef	14.8[7]	25.86 ab	1.92 bc	27.78 ab	28.86[10]	57.60 bc	61.97[10]	0.36 e	---	19542 ab	---
Paubrasilia echinata	35.06 a	24.9[8]	26.57 a	2.15 bc	28.72 ab	21.15[11]	36.22 e	83.78[11]	0.35 e	1.86[14]	19949 a	---
Peltophorum dubium	24.38 c	---	26.77 a	1.64 c	28.41 ab	---	47.20 d	---	1.35 bc	1.37[15]	18728 cde	19454[17]
Terminalia argentea	16.17 e	---	27.56 a	1.89 c	29.45 a	---	54.38 c	---	0.65 e	---	18837 cd	---

Contents of total extractives (Ex), insoluble lignin (Li), soluble lignin (Ls), total lignin (Lt), holocellulose (Ho), ash (As) and higher heating value (Hhv). Means followed by different letters (in column) indicate statistical significance by Bonferroni test ($p < 0.05$). 1. (Santos, 2021), 2. (Silva, 2018), 3. (Lobão et al., 2011), 4. (Carli et al., 2016), 5. (Campelo et al., 2017), 6. (Dias et al., 2013), 7. (Oliveira et al., 2012), 8. (Schimleck et al., 2009), 9. (Batista et al., 2018), 10. (Longui et al., 2017), 11. (Dias et al., 2013), 12. (Silva et al., 2017), 13. (Farias, 2012), 14. (Silva et al., 2021), 15. (Vale et al., 2005), 16. (Romero et al., 1985), 17. (Amorim et al., 2020). Source: Authors.

Recent studies have shown new applications for cellulose. Materials molded with wood cellulose fibers are of interest as eco-friendly alternatives to petroleum-based glass fiber/polymer composites. Specifically, molded fiber materials may compete with molded glass fiber reinforced plastics in terms of mechanical performance per weight, better recyclability, and lower values for embodied energy in the final material (Yang, 2019).

In the area of technological innovation, a growing market is the production of nanocrystalline cellulose, a light, transparent material, eight times stronger than stainless steel. It is extracted by processing wood pulp. The manufacture of nanocrystalline cellulose requires the removal of lignin and hemicellulose, resulting in hard, dense, and rigid nanofibrils which can be pressed into different shapes and sizes. Such material is light, absorbent, and a good thermal and acoustic insulator. As nanocellulose is only 2 nanometers long, it is possible to use branches, twigs, and sawdust. The expectation is that nanocellulose will make most plastics obsolete since its physical properties allow it to replace even metals in the construction of car parts (Inovação Tecnológica, 2024). Within this context, it is possible to envision the potential of native Latin America wood species for raw materials, whether from reforestation wood or pruned residues.

Native woods can also be used in paper production. This calls for careful analysis of anatomical indices and chemical constituents, along with the viability of producing paper Latin America natives, particularly since *Pinus* spp. and *Eucalyptus* spp. woods already have undergone decades of industrial development. Perhaps, native wood residues can be used on a smaller scale or even offer a different type of paper that meets some market demands. In studied the physio-anatomical properties of *Cedrelinga cateniformis* and *Martiodendron elatum* woods and their correlations. These authors verified that *Cedrelinga cateniformis* wood presents results closer to those observed for *Eucalyptus* spp. for anatomical indices of wood quality appropriate for paper production (Silva and Evangelista, 2021). Other authors studied 20 clones of *Hevea brasiliensis* to verify their potential for use in pulp and paper, also based on anatomical indices of wood quality for paper production. The clones that presented better results for fiber quality indexes were IAC 311, IAC 41, IAN 873, IAC 326, IAC 40 and RRIM 725 (Amorim et al., 2021). Enabling the use of wood after the latex exploration cycle for pulp and paper will serve as a basis improving the gene pool of these clones and expanding forest plantations for pulp and paper. Even without studying the percentages of extractives, lignin and holocellulose, the reports (Silva 2005; Silva and Evangelista, 2021) mention *Calophyllum brasiliense* wood as an example of how Latin America native woods can be considered for use as pulp and paper.

Inorganic wood content is typically called ash content (Rowell 2013). The ash content of wood is normally low, less than 1 % of the dry weight of wood (Pettersen, 1984). Inorganic content can, however, be quite high in woods containing large amounts of silica. In most cases, though, inorganic content is less than 0.5 % (Browning, 1967). In the present study, six woods presented values higher than 1 %, namely *Annona crassiflora*, *Balfourodendron riedelianum*, *Cariniana legalis*, *Genipa americana*, *Handroanthus vellosoi*, and *Peltophorum dubium*. This may indicate a pattern that varies among Latin America natives.

According to the Brazilian market, values between 16500 and 18000 kJ kg^{-1} are suitable for use in bioenergy (Menucelli et al., 2019). Therefore, based on the values found in the study, all species have potential for use in bioenergy. For direct burning, it is suggested that wood with a higher heating value be used as it is positively related to energy yield which, in turn, is related to its contents of cellulose, hemicelluloses, lignin, extractives and mineral substances (Quirino et al., 2005). Obviously, as many of the woods studied here are noble woods, direct burning of these woods is wasteful, but the use of residues can be explored to provide new avenues of commercialization. For example, transformation of residues into pellets and briquettes increases HHV compared to raw wood (Telmo and Lousada, 2011; Artemio et al., 2018). Additionally, some companies have used wood chips, especially fruit species, for grilling/smoking and offering different aromas and flavors to the barbecue or cocktail. However, prior wood testing is always essential to ensure the absence of toxicity harmful to human health.

4. Conclusion

In summary, chemical characteristics varied among species. Differences in wood chemical characteristics compared with the results of other studies result from different collection sites, soil composition and tree age. In this study, we have proposed a broad range of new uses for native Latin America woods, according to their chemical characteristics, envisioning their enormous potential. For example, wood with high extractive content can offer colored materials desirable for the manufacture of furniture. Extractives can also be incorporated into other woods to improve their physicomechanical performance or even studied for specific purposes according to their properties. Wood with high lignin content is not initially desirable in the production of cellulosic pulp; however, high lignin content in wood may indicate greater rigidity and potential use in construction or parts that require greater mechanical demand. Thinking in terms of technological innovation, native woods can be a viable source of renewable raw material for the manufacture of nanocrystalline cellulose. Finally, all 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.

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