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# Characterization of the chemical properties of threeplant species of the Cerrado biome

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## ABSTRACT

The focus of this article was to carry out studies and analyses in order to establish the chemical constitution of the wood of three species found in the Cerrado Biome, namely: Tachigali vulgaris, Myracrodruon urundeuva and Amburana cearensis. Initially, samples were collected based on the probability and, mainly, on the commercial preference of the woods. Discs were removed along the stem (0%, 50%, and 100% of the height) of the randomly selected trees considering the condition of good stem and straight grain. Thus, specimens were removed from the samples, converted into sawdust to determine the chemical properties of the woods. The sawdust passed through the 0.425 mm and 0.250 mm sieves, respectively, the fraction used to determine the percentage of total extractives, lignin and holocellulose was retained in the 0.250 mm sieve and passed through the 0.425 mm sieve. The analysis of the results indicated that the chemical composition of the woods of the species studied was compatible with the normal pattern for broadleaves. The resulting information also indicated that Amburana cearensis has a higher basic specific mass, because the holocellulose content is inversely proportional to that of lignin. Amburana cearensis and Myracrodruon urundeuva showed higher extractive content, providing greater natural durability. Lignin in the tissues provides resistance to xylophagous attack, as a result, the species Amburana cearensis is possibly the most vulnerable to attacks. However, in the species studied, the chemical constitution of the wood can be significantly correlated with the technological behavior.


**Keywords:** Xylophages, Holocellulose, Lignin.

## INTRODUCTION

Tree species have unique characteristics; In addition to differing between species, they differ between individuals of the same species and even in regions of the wood of a single individual. Marcati (1992) states that numerous factors, both internal and external to the tree, lead to variations in the type, number, size, shape, physical structure and chemical composition of the elements. Thus, the configuration is described by the organization and proportional quantity of various types of cells, such as fibers, tracheids, vessels, axial parenchyma and rays, significantly influencing the various properties of the wood.

The distinction is not limited to the chemical and biochemical patterns along the tree wood, it is also identified in the arrangement of the elements. Thus, despite the scientific advances in the area of wood technology, there is still a lot of difficulty in defining the correct purpose of certain native species.

According to (PANSHIN & DE ZEEUW, 1970), the structure of broadleaves is more complex than that of conifers since more cellular elements enter their constitution. Most of the cells — from

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90% to 95% — are aligned on the vertical axis, resulting in a differentiated distribution of cells on the three main axes and, consequently, in the maximum degree of anisotropy existing in wood (DINWOODIE, 1981).

According to SILVA (2010), the extractive has a profound effect on the properties of the wood, influencing the characteristics that the woods of different species present. The natural durability of wood is related to the toxicity of the extractives in it. Some cause erosion and/or corrosion in the tooling or influence the final treatment of the work.

When solid wood is used, the existence of certain chemical groups and the extractive content play a significant role, since they are directly associated with the natural longevity of wood and, thus, can adapt or increase its use. On the other hand, high levels of cellulose are associated with a higher tensile strength of solid wood, while high levels of lignin increase compressive strength (SILVA, 2010).

In recent decades, concern for the environment has increased. Thus, campaigns about sustainable forest management have also increased, but managing the forest is not an easy task. Brazil is a country that has an enormous wealth of tree species, this richness is related both in number of individuals and in species diversity. The National Forest Information System (SNIF) considers that Brazil is home to one of the most diverse and exuberant floras on the planet.

This variety found in Brazilian forests, especially in the region under study, is often the motivator for the inappropriate use of wood. Despite the visual similarities between some species, their physical, chemical and anatomical characteristics can be completely different, being able, in certain situations, to cause problems in their use. The understanding of these properties allows us to point out the best uses of wood, thus avoiding inconveniences related to its inappropriate use.

According to (SILVA, 2010), the chemical structure of wood defines its behavior, so knowing the chemical properties of the species is of great importance to designate the best techniques of forest management and improvement, silvicultural conducts, enabling the best use of wood as raw material. The chemical structuring of wood is of great importance, in view of its influence on some of the properties that define the suitability of wood for various end uses. Natural durability, workability, color, mechanical resistance, and energy power are affected by the quality and quantity of the components in its structure (SILVA, 2010).

In research aimed at optimizing charcoal production, among the various relevant factors, the knowledge of lignocellulosic contents has been shown to be of great importance, since these contents directly influence the yield of charcoal production.

In the evaluation of several potential wood qualities for charcoal production, the calculation of the lignin content is fundamental, since the presence of it increases the yield of charcoal production, in addition to increasing its calorific value, because lignin has greater resistance to thermal degradation, a consequence of the bonds between the constituent carbons of the phenyl-propane units present in its structure.

On the other hand, holocellulose (cellulose and hemicellulose together) does not have great resistance to degradation due to increased temperature, especially hemicellulose, which in an amorphous and branched structure, ends up being easily degraded with increasing temperature.

Brazil is one of the largest producers of charcoal in the world, especially in the state of Minas Gerais, where the largest consumers of this resource are found within the steel industry.

In this context, the concern with a better yield in the production of charcoal to supply these sectors has intensified research in the search for species with characteristics that provide this yield. Some studies, for example, seek to evaluate the difference in chemical composition between the different morphological parts that make up the trunks of trees and also seek to evaluate how these properties are achieved during the growth stages of the species.

In view of the above, the process of selection and characterization of wood is of fundamental necessity. Therefore, the general objective of this elaboration was to carry out chemical analyses on the species Tachigali vulgaris, Myracrodruon urundeuva and Amburana cearensis that have relevant economic interest and are found in the Cerrado Biome.

## MATERIAL AND METHODS

In order to carry out the present work, wood samples of the species Tachigali vulgaris (Carvoeiro), Myracrodruon urundeuva (Aroeira) and Amburana cearensis (Cumaru) were analyzed. All the species used are broadleaves from the Cerrado Biome and were chosen according to availability in the places visited and, mainly, for commercial interest.

The collection was randomly selected, considering good stems and straight grains, and slaughtered. After slaughter, three discs of approximately 5 cm thickness were removed along the stem, at 0 %, 50% and 100% of the height.

From the samples, the material was prepared for the study of the following chemical properties of the wood: total extractives, lignin and holocellulose (cellulose + hemicellulose).

The samples went through the process of cavaqueamento and were then transformed into sawdust with the help of a mill. The sawdust passed through the 0.425 mm and 0.250 mm sieves, respectively, the fraction used in this determination is the one that passes through the 0.425 mm sieve, but is retained in the 0.250 mm sieve. With the resulting sawdust, the percentage of total extractives, lignin and holocellulose was determined.

- **Determination of Total Extractives**

This analysis was carried out according to the TAPPI T2O4 cm-97 standard (TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY, 1997b), adapted, using the following materials: wood sawdust (fraction 0.250 mm / 0.425 mm), chemical reagents (ethyl alcohol, toluene and distilled water), complete Soxhlet extractor, 600mL beaker, filter paper in cartridge form, vacuum pump, funnel, kitassato, desiccant, water bath, glass stick, piste, tweezers, precision scale, petri dish and oven regulated at 105±3ºC.

The fully dry weight of extractive-free timber (P2) is determined as follows:

P2 = (Weight of Petri Dish + Extractive-Free Wood Sawdust) - Weight of Empty Petri Dish.

The total extractives content is obtained according to the equation:

$TE\% = ( P1 - P2 ) / P1 \times 100.$

Where:

TE% = Total extractives content, in percentage;

P1 = Totally dry weight of the wood with extractives, in grams;

P2 = Totally dry weight of the extractive-free wood, in grams.

- **Determination of Lignin**

This analysis was carried out according to the TAPPI T222 om-98 standard (TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY, 1997e), using the following materials: extractive-free wood sawdust (fraction 0.250 mm / 0.425 mm), chemical reagents (distilled water and sulfuric acid -$H_2SO_4$- at a concentration of 72%), 600mL beaker, 15mL pipette, glass rod, thermometer, heating plate, plastic basin, sintered glass crucible, kitassato, vacuum pump, precision scale, desiccator and oven regulated at 105±3ºC.

The weight of the lignin residue (P1) is calculated as follows:

P1 = (Weight of Sintered Glass Crucible + Residue) - Weight of Empty Sintered Glass Crucible.

The lignin content is quantified according to Equation:

$L\% = P1/ P2 \times 100.$

Where:

L% = The lignin content of the sample, in percentage;

P1 = Residual weight of lignin, in grams;

P2 = Initial weight of the wood sample (a.s), free of extractives, in grams.

As the calculation takes into account the wood free of extractives as being 100%, the value found must be corrected, and this correction is defined by the expression:

LCor = P1/ P2 x (100 - TE%).

Where:

LCor = Lignin content after correction, in percentage;

P1 = Residual weight of lignin, in grams;

P2 = Initial weight of the wood sample (a.s), free of extractives, in grams;

TE% = Extractive content of the wood sample, in percentage.

- **Holocellulose Determination**

This analysis was carried out according to the methodology developed by Wise et al. (1946), by the method of delignification in acid medium. The materials used consist of: extractive-free wood sawdust (Fraction 0.250 mm /0.425 mm), chemical reagents (distilled water, glacial acetic acid -$CH_3COOH$, sodium chlorite -$NaClO_2$, sodium acetate -$CH_3COONa$, 250mL Erlenmeyer, 100ml volumetric flask, sintered glass crucible, glass rod, heating plate, fume hood, plastic basin, water bath, vacuum pump, 1mL pipette, kitassato, precision scale, desiccator and oven regulated at 70ºC.

The weight of holocellulose (Ph) was calculated as follows:

Ph = (Weight of Sintered Glass Crucible + Holocellulose Sample) - Weight of Empty Sintered Glass Crucible.

The holocellulose content was calculated according to the equation:

H% = Ph/P x 100.

Where: H% = Holocellulose content, in percentage;

Ph = Weight of holocellulose, in grams;

P = Initial weight of the sample of dry wood, free of extractives, in grams.

The holocellulose content must be corrected considering the extractives content of the sample, according to Equation:

HCor = H% × (100 - TE%).

Where:

HCor = Corrected holocellulose content, in percentage;

H% = Holocellulose content, in percentage;

TE% = Extractive content, in percentage.

The percentage was determined by the following equations:

% EXT ——(1 — P. a.s. serragem) x 100

%LIG ——(PST — T) x 100

%HOLO ——100 - %EXT - %LIG

Where:

%EXT ——percentage of total extractives;

%LIG —- percentage of lignin;

% HOLO ——percentage of holocellulose;

PST ——weight of residue plus tare;

T = crucible tare;

P.a.s. = Weight to be shown seca.

## RESULTS AND DISCUSSION

The chemical analysis determined the extractives, lignin and holocellulose contents as shown in table 1.

According to the result presented in Table 1, the chemical composition of the species studied presented values within the normal standard for broadleaves, according to (KLOCK et al., 2005).

Table 1. Chemical analysis of the species studied

| Species | Total Extractive (%) | Lignin (%) | Holocelulose (%) |
|---|---|---|---|
| Tachigali vulgaris | 9,98 | 31,34 | 57,54 |
| Myracrodruo Urundeuva | 12,75 | 27,13 | 59,04 |
| Amburana cearensis | 27,04 | 21,14 | 49,27 |

Source: The author.

Table 1 also indicates that the species Myracrodruon urundeuva and Amburana cearensis were the ones with the highest extractive content, 12.75% and 27.04%, respectively. SILVA et al. (2004) stated that the core of wood with a higher percentage of extractives has greater natural durability. Therefore, we can assume that the species Myracrodruon urundeuva and Amburana cearensis are the most naturally durable, while this characteristic is lower in the species Tachigali vulgaris.

According to Philipp (1988), the presence of lignin in tissues confers resistance to attack by xylophagous organisms, as it prevents the penetration of enzymes that destroy the cell wall. Thus, based on the data presented in Table 1, it is possible to state that the species Myracrodruon urundeuva (27.13%) and Tachigali vulgaris (31.34%) are more resistant to attack by microorganisms, when compared to the species Amburana cearensis (21.14% lignin content).

Thus, the results indicate that as the holocellulose content increases, the lignin content decreases. TRUGILHO et al. (1996) in studies with eucalyptus, stated that the higher the holocellulose content, the greater the basic specific mass of the wood species. Thus, among the species studied, Myracrodruon urundeuva would have the highest basic specific mass.

According to Paula (1993), for wood, cellulose and lignin are the basic substances used for energy generation. Therefore, from an ecological and economic point of view, woods rich in these substances are the most viable and promising for energy production. However, when considering charcoal production, yield is closely related to the chemical composition of the wood, with regard to high levels of lignin.

It is worth mentioning that the temperature of 450ºC is the maximum temperature recommended for the production of charcoal, since at this temperature it is possible to achieve higher yields to the quality of charcoal. From this temperature, the degradation of lignin begins to be more intense, which impairs the yield and properties of charcoal. The condition of burning wood for energy production is considered ideal when it is absolutely dry, but it is also influenced by its chemical constitution, lignin and extractives, which increase its potential (QUIRINO et al., 2005).

The lignin content was 31.34% for Tachigali vulgaris while the amount of ash present in it was 1.14%. When observing the values found for the content of total extractives present in the wood of Tachigali vulgaris, it was found that 9.98% was found.

The amount of organic materials, i.e., extractives that were isolated, was found for Myracrodruon urundeuva (12.75%). The lignin levels found in the species under study were also shown for Myracrodruon urundeuva (27.13%). The holocellulose content found was 59.04%. The gross energy analysis performed to determine the higher calorific value of Myracrodruon urundeuva yielded 4,659.633 kcal/kg.

## CONCLUSIONS

Evaluating the results, it is verified that the chemical composition of the wood of the native species of the Cerrado Biome presented values compatible with those obtained in previous studies. Considering the species analyzed, their chemical composition can be correlated, in a relevant way, with their technological performance.

The properties of chemical composition and immediate analysis are important as a subsidy to assist in the selection of species according to the final use. However, it would be a mistake to evaluate them in isolation. For density, according to the species studied, it is noted that the higher the basic density of wood, the higher the apparent density of charcoal.

The native species with the best characteristics with energy potential for rapid burning are Tachigali vulgaris and Amburana cearensis, while for slow burning and charcoal production, the best species is Myracrodruon urundeuva.

The species Myracrodruon Urundeuva proved to be of good quality in its physical, chemical and energetic properties, but its use should be restricted and in the form of management, considering that this species is endangered. Likewise, the wood of Amburana cearensis showed good quality in the properties studied, and can be used without exploitation restrictions, since it is a species with excellent adaptability to the existing conditions in the biome in question.

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