

Energetic characterization of Matá-Matá wood from
the brazilian rainforest (*Eschweilera* Mart Ex Dc)Caracterização Energética de madeiras de espécies conhecidas
na Amazônia brasileira como Matá-Matá (*Eschweilera* Mart Ex Dc)Victor Hugo Pereira Moutinho¹, Allan Motta Couto², José Tarcísio Lima³,
Osmar José Romeiro de Aguiar⁴ e Mariana de Oliveira Gonçalves Nogueira⁵**Abstract**

Despite the great diversity of the Amazon rainforest, only a limited number of tree species is used; resulting in only partial use of forest areas. This has technical, economic and environmental disadvantages. Many frequent species of the Brazilian Amazon are suitable to forest management but are not commercialized due to ignorance about their properties. Matá-matá of the genus *Eschweilera* Mart. Ex DC., Lecythidaceae, is one of these. We characterized its wood physically, chemically as well as its energetic potential. Matá-matá wood's main chemical component levels, that is: high calorific value (HCV); basic density (BD) and energetic density (ED) were examined, and compared to a *Eucalyptus* sp. clone wood commonly used for energy. *Eschweilera* sp. wood had higher values in BD, ED, lignin and mineral content than those of *Eucalyptus* sp. Matá-matá wood had better physical and chemical characteristics for energy than most woods commonly used in the region.

Keywords: *Eschweilera*, matá-matá, wood chemistry, energy and characterization.

Resumo

Apesar da grande diversidade da Floresta Amazônica, apenas um número restrito de espécies arbóreas é explorado, resultando em um aproveitamento parcial das áreas florestais em exploração, com consequências técnicas, econômicas e ambientais desvantajosas. Muitas espécies de grande frequência na Amazônia brasileira, aptas ao manejo florestal, algumas vezes não são comercializadas por desconhecimento de suas propriedades, entre estas, cita-se o gênero *Eschweilera* Mart. Ex DC. – Lecythidaceae, popularmente conhecido como matá-matá. Tendo isto em vista, o presente trabalho objetivou caracterizar física e quimicamente, e avaliar o potencial energético da madeira de *Eschweilera*. Para tanto, determinou-se os teores dos principais componentes químicos, poder calorífico superior (PCS), densidade básica (DB) e a densidade energética (DE) da madeira de 11 indivíduos de matá-matá. Os resultados observados foram comparados com os obtidos a partir de um clone de *Eucalyptus* comumente utilizado como fonte energética. As madeiras de *Eschweilera* sp., comparativamente ao *Eucalyptus*, apresentaram maiores valores de DB, DE, teor em lignina e minerais. A madeira de matá-matá apresenta características químicas e física superiores às espécies comumente utilizadas como fonte de energia.

Palavras-chave: *Eschweilera*, matá-matá, química da madeira, energia e caracterização.

INTRODUCTION

Within the Brazilian rainforest territory there are huge sources of iron oxide. Due to this mineral abundance many multinational companies are exploring wood for pig iron production.

The conversion process of iron oxide into pig iron requires large amounts of reducing material and energy. In Brazil, the main thermo-reducing source used in pig iron production is charcoal.

Industries need a constant supply of charcoal. Many woody species without commercial value but high energetic value could be used. Matá-matá, of the genus *Eschweilera* Mart. Ex DC. (Lecythidaceae), is abundant in the Amazon Forest and it is not used due to lack of information.

Steege *et al.* (2006), sampling a quarter of a million trees with more than 30cm of diameter in continental Amazonia, saw that *Eschweilera* is the most abundant (5.6%) genus in the Amazon

¹Msc. in Ciência e Tecnologia da Madeira. Professor Assistente da Universidade Federal do Oeste do Pará - E-mail: victor.ctmadeira@gmail.com

²Msc. in Ciência e Tecnologia da Madeira. Universidade Federal de Lavras - E-mail: allan_floresta@yahoo.com.br

³PhD. in Forest Science. Professor Associado II da Universidade Federal de Lavras - E-mail: jtlima@ufla.br

⁴PhD. en Sciences Forestier Et Du Bois. Pesquisador da Embrapa Amazônia Oriental - E-mail: o_aguiar@cpatu.embrapa.br

⁵Engenheira Florestal, Universidade Federal de Lavras - E-mail: mari.florestal@yahoo.com.br

forest. A forest inventory of 3000 hectares made in Floresta Nacional do Tapajós found this genus to account for 8,752% of the total; each sub-plot containing a minimum of four different species of *Eschweilera* (OLIVEIRA *et al.*, 2011).

Lima *et al.* (2002), studying the natural regeneration of three areas used for wood exploration, found that species of the *Eschweilera* genus regenerated well. The intensity of logging did not reduce the density of these species, indicating that they are regeneration generalists and consequently can survive in or around large forest gaps. Few studies have been done to characterize the wood of this genus technologically, so as to introduce it to the market.

More studies about Amazonian woods are needed since the lack of knowledge about a given wood is an obstacle for its rational use. For energy and charcoal production wood should have a high basic density and calorific values, high lignin and low mineral content.

This study is to shed some light on the chemical, physical and energetic characteristics of matá-matá for its potential as an energy source.

MATERIALS AND METHODS

Wood samples were collected in Paragominas - PA. Thirteen trees popularly known as matá-matá were randomly cut in a primary forest area, according to established guidelines for low-impact forest management. After proper identification by experts, botanical material from each tree was collected and registered at Embrapa's Eastern Amazon Herbarium. For comparison four plants of a *Eucalyptus* clone commonly used in charcoal production at age five, was collected from Bom Jardim de Minas, southern Minas Gerais state, in an planted forest area, where ecological (soil and climatic) conditions are, however, not similar at all to those of Paragominas.

Wood shavings were removed at different heights of the trunk with the aid of an electric planer, and these were reduced with a Willey mill. The pieces were then separated with a set of screens and classified according to size. The fraction retained between mesh 40 and 60 was placed in a climatic chamber at 20 ± 3 °C and $60 \pm 5\%$ of air moisture to stabilize the wood moisture content around 12%.

The basic density test was done by the guidelines established by NBR 11941 (ABNT, 2003), while the total extractives analysis,

inorganic compounds and lignin contents followed the procedures suggested by Brazilian Cellulose and Paper Technical Association (ABTCP, 1974).

Wood High Calorific Value (HCV) was determined in a calorimetric pump, model C200 ICA, according to analytical norm NBR 8633 (ABNT, 1983). Energetic Density (ED) was obtained using the relation between BD and HCV (Equation 1).

$$ED = BD \times HCV \quad (1)$$

Where:

ED: Energy Density in cal/cm³;

BD: Basic Density in g/cm³, and

HCV: High Calorific Value in cal/g

Statistical analysis

Given the great diversity of species of the studied genus and the lack of taxonomic studies on these species, two species of matá-matá were represented by a single individual (*Eschweilera ovata* and *E. amazonica*), so it was not possible to perform the ANOVA with them. Except for this, the statistic design was completely randomized, with four treatments and a variable number of replications; 2, 2, 4 and 4 replicates for *E. coriacea*, *E. amazonica*, *E. idatimon* and *Eucalyptus* sp. respectively. Table 1 shows the number of individuals evaluated for each species.

Table 1. Number of individuals evaluated for each species.

Tabela 1. Número indivíduos avaliados para cada espécie.

Material	Number of individuals (Replicates)
<i>Eucalyptus</i> (1 144)	4
<i>Eschweilera idatimon</i>	2
<i>Eschweilera amazonica</i>	4
<i>Eschweilera coriacea</i>	2
<i>Eschweilera ovata</i>	1
<i>Eschweilera amazonica</i>	1
<i>Eschweilera</i> sp.	1

For multiple comparisons of means, the Scott-Knott test at 5% significance level was used.

RESULTS AND DISCUSSION

The variance analysis showed a significant difference at 5% significance for lignin content (LIG), mineral content (MIN), total extractives (TOT E.), basic density (BD) and energetic density (ED). It No statistical difference for high calorific value (HCV) at that significance level was found.

Table 2. Summary of variance analysis for physical and chemical properties of wood.
Tabela 2. Resumo da análise de variância para as propriedades químicas e física dos materiais.

VS	FD	MS					
		LIG	MIN	TOT E.	HCV	BD	ED
Species	3	25,31*	5,34*	26,74*	10655,89 ^{ns}	0,150*	3073242,08*
Error	8	3,06	0,02	2,37	34.465,	0,000	63.617
Exp VC (%)	6,24	7,13	26,55	4,11	3,27	7,48	

VS: Source of Variation, FD: Degrees of Freedom, MS: Medium Square; LIG: Lignin Content, MIN: Mineral Content, TOT E.: total extractives content; HCV: High Calorific Value; BD: Basic Density; ED: Energetic Density; Exp VC (%): experimental variation coefficient, and *: Significant at a 5% significance level; ens: Not significant at a 5% significance level.

The results of means multiple comparison according to the Scott-Knott test at 5% significance level are shown in Table 3. It also gives a characterization of the three species which were not analyzed due to lack of replicates. There is a significant variation among the studied species.

According to Bodig and Jayne (1982) there is a great quantitative variability of chemical components in wood of the same species and even within the same individual. Pettersen (1983) explains this phenomenon considering the parts of the tree from which the sample was removed, as well as considering the different environmental conditions under which it grew. Although the material for chemical analysis was taken from similar tree heights, the variation can be explained by the environmental conditions under which individuals grew. Although they were in close by areas; local factors such as forest clearings, spacing between trees, water access, as well as xylophagous organisms may have differed. To Santana and Okino (2007), this variation may also be explained by the age of trees collected. Since the collection area is the rainforest, their age varies considerably even in a small area.

The similarity of High Calorific Value - HCV on the evaluated material may be due to low variability on the elementary contents (carbon, hydrogen and oxygen), which are almost constant in the wood (BRITO; BARRICHELO, 1979).

E. grandiflora and *E. idatimon* lignin content (LIG) did not differ significantly from that of

Eucalyptus sp. content collected in a different place, and which is commonly used for power generation. Lignin is the most resistant chemical compound to thermal degradation when compared to other essential components present in wood, and about 50% of its mass contributes to coal residual formation (CETEC, 1989). Such features, among others, turn lignin into the most desired wood compound when the goal is to generate energy using forest biomass. Trugilho *et al.* (1996) studying *Eucalyptus* aged 12 to 48 months, found lignin contents ranging from 24 to 27%; values which are lower than for most other species examined here.

Despite the statistical similarity between *Eucalyptus* sp., *E. grandiflora* and *E. idatimon* for total extractives content (TOT E.) there is a slight superiority of the Amazonian species when compared to *Eucalyptus* sp. This could be due to the heartwood formation process, when there is a greater deposition of these compounds into the cell wall (Trugilho *et al.*, 1996) but could also be due to the different origins of growth of *Eschweilera* sp and *Eucalyptus* sp. Heartwood formation process occurs throughout the tree's life-span, but is more intense in older individuals (METCALF; CHALK, 1983).

Amazonian species BD was significantly higher than that of *Eucalyptus* sp. BD. This result may stem from genetic, age and site differences, since *Eucalyptus* sp. individuals were five years old and collected in a completely different place than the native species which were significantly older.

Table 3. Results of means multiple comparison according to Scott-Knott test at 5% significance level. Characterization of the species not analyzed in the analysis of variance because there were no replicates.

Tabela 3. Resultado da comparação múltipla de médias segundo teste Scott-Knott a 5% de significância. Caracterização das espécies impossibilitadas de entrar na análise de variância devido à falta de repetições.

Species	LIG	MIN	TOT E.	HCV	BD	ED
		%		cal/g	g/cm ³	cal/cm ³
<i>Eucalyptus</i> sp.	27,07 A	0,27 A	3,65 B	4557,25 A	0,475 C	2169,83 B
<i>E. coriacea</i>	23,42 B	1,99 B	11,16 A	4438,03 A	0,885 A	3926,62 A
<i>E. grandiflora</i>	30,56 A	2,94 C	5,99 B	4559,37 A	0,920 A	4200,33 A
<i>E. idatimon</i>	29,48 A	2,64 D	4,36 B	4461,54 A	0,800 B	3570,99 A
<i>E. ovata</i>	30,84	2,08	3,63	4758,41	0,870	4139,8
<i>E. amazonica</i>	28,38	2,18	5,76	4531,39	0,950	4304,8
<i>Eschweilera</i> sp.	27,57	2,89	5,34	4577,07	0,870	3982,1

LIG, lignin content; MIN: mineral content, TOT E.: total extractives content; HCV: High Calorific Value; BD: Basic Density; ED: Energetic Density

Amazonian species mineral content (MIN) was higher in comparison to *Eucalyptus* sp. These values may be considered high when compared to most *Eucalyptus* sp. species, which rarely exceed 1%, according to Tsoumis (1991). However, Pettersen (1983) reports that ash values for tropical wood may often be much higher, sometimes presenting values close to 13%, as Ipê wood (*Tabebuia guayacan*). Inorganic compounds content in wood may vary according to environmental conditions during growth. Bergstrom (1959) apud Buchana (1975) exemplifies this with *Syncarpia lourifolia* individuals, where wood from clones, treated similarly, had silica content of around 0.6% for Australian trees and 0.09% for Hawaiian trees. According to Martins (1980) minerals are compounds that do not degrade under organic compounds combustion temperature, thus they are undesirable elements in compounds intended for power generation.

The energetic density of Amazonian species (ED) was also higher than that of *Eucalyptus* sp. ED. This result is related to BD's influence on this trait. We infer that denser woods are more desirable when the goal is energy generation.

Table 4 shows Pearson correlations between the variables. There are strong and positive correlations between ED and the variables HCV and BD. This result is explained by the fact that ED originated from the relation between HCV and BD. There is also a strong negative correlation between TOT E. and LIG. This may indicate that higher lignin content is related to lower total extractives content.

Figures 1 and 2 show the relationship between ED/BD and ED/HCV respectively: there is a strong relation between DB and the variables BD and HCV. Cunha *et al.* (1989) working with 55 native species observed the same relation between these variables.

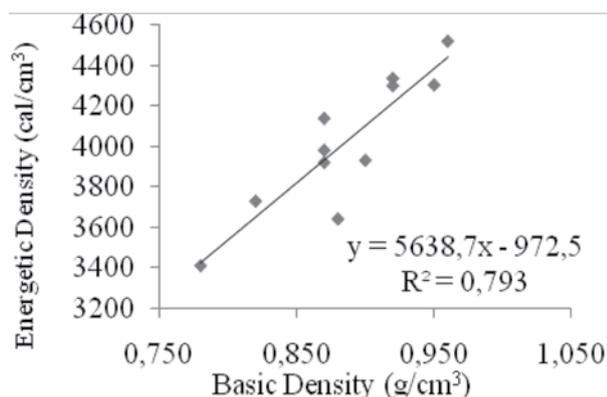


Figure 1. Functional relation between ED and BD.
Figura 1. Relação funcional entre DE e DB.

Table 4. Pearson correlations between certain properties of evaluated material.

Tabela 4. Correlações de Pearson entre as propriedades determinadas dos materiais avaliados.

	LIG	MIN	TOT E.	HCV	BD	ED
LIG	1,00	0,45	-0,79	0,45	0,19	0,35
MIN		1,00	-0,40	-0,06	0,01	-0,01
TOT E.			1,00	-0,39	0,18	-0,06
HCV				1,00	0,36	0,75
BD					1,00	0,89
ED						1,00

LIG: lignin content; MIN: mineral content, TOT E.: total extractives content; HCV: High Calorific Value; BD: Basic Density; ED: Energetic Density

CONCLUSIONS

- *Eschweilera* Mart. Ex DC. (Lecythidaceae) wood had high Density and Lignin and Mineral content values. It also had similar high calorific value as the species commonly used for power generation.

- There is not a correlation between Density and High calorific value for the studied species but there is a strong correlation between those values and energetic density.

- *Eschweilera* Mart. Ex DC. (Lecythidaceae) wood had better characteristics than those of the studied *Eucalyptus* sp. Mata-matá wood properties are compatible with energy generation requirements.

REFERENCES

ABTCP - ASSOCIAÇÃO BRASILEIRA TÉCNICA DE CELULOSE E PAPEL. Normas técnicas ABTCP: M 3/89 e M 11/77. São Paulo, 1974.

ABNT - ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 8633- Carvão vegetal - Determinação do poder calorífico - Método de ensaio. Rio de Janeiro, 1983. 13p.

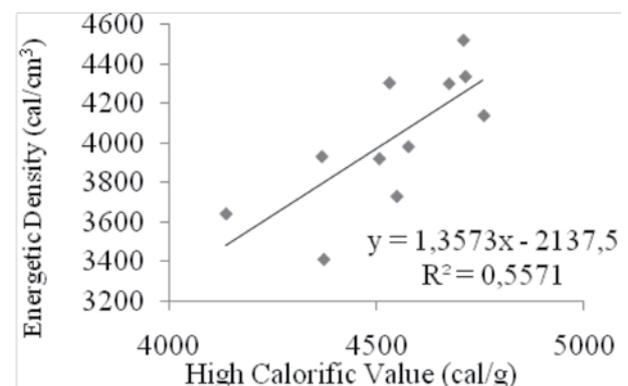


Figure 2. Functional relation between ED and HCV.
Figura 2. Relação funcional entre DE e PCS.

- ABNT - ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 11941 - Madeira- Determinação da densidade básica. Rio de Janeiro, 2003, 6p.
- BODIG, J.; JAYNE, B.A. **Mechanics of wood and wood composites**. New York: Van Nostrand Reinhold Company, 1982. 712p.
- BRITO, J.O.; BARRICHELLO, L.E.G. Correlações entre características físicas e químicas da madeira e a produção de carvão vegetal: i. Densidade e teor de lignina da madeira de eucalipto, **IPEF**, Piracicaba, n.14, p.9-20, 1977.
- BRITO, J.O.; BARRICHELLO, L.E.G. Usos diretos e propriedades da madeira para geração de energia. **Circular Técnica IPEF**, Piracicaba, n.52, 1979. 7p.
- BUNCHANAN, M.A. Extraneous components of wood. In: ____ **The chemistry of wood**. New York: Ed. Browning, B.L. Robert Krieger Publishing Company, 1975. p.313-368.
- CUNHA, M.P.S.C.; PONTES, C.L.F.; CRUZ, I. A.; CABRAL, M. T. F. D.; CUNHA NETO, Z.B.; BARBOSA, A.P.R. Estudo químico de 55 espécies lenhosas para geração de energia em caldeiras. In: ENCONTRO BRASILEIRO EM MADEIRAS E EM ESTRUTURAS DE MADEIRA, 3., 1989, São Carlos. **Anais.**, São Carlos: USP, 1989. v.2, p.93-121.
- LIMA, P.L.; LIMA, O.P.; MAGNUSSON, W.E.; HIGUCHI, N.; REIS, F.Q. Regeneration of Five commercially-valuable tree species after experimental logging in the Amazonian forest. **Revista Árvore**, Viçosa, v.26, n.5, p.567-571, 2002.
- MARTINS, H. Madeira como fonte de energia. In: PENEDO, W.R. (Ed). **Uso da madeira para fins energéticos**. Belo Horizonte: CETEC - Centro Tecnológico de Minas Gerais, p.9-26, 1980.
- METCALE, C. R.; CHALK, L. **Anatomy of the dicotyledons, wood structure and conclusion of the general introduction**. Oxford: Clarendon Press, 1983. 297pp.
- OLIVEIRA, L.M; SOUSA, L.K.V.; MOUTINHO, V.H.P; SILVA, U.C.S. da; AGUIAR, J.O.R. de; CARVALHO, J.O.P. de; MELO, M.S. Estudo fitossociológico e tecnológico de novas espécies madeireiras em três áreas de manejo florestal sustentável em assentamentos agrários na região de Santarém, PA. Brasília: CNPQ, 2011. 143p. **Relatório técnico**.
- PETTERSEN, R.C. The chemical composition of wood. In: ROWELL, R.(ed). **The chemistry of solid wood**. Washington: American Chemical Society, 1984. p.54-126.
- SANTANA, M.A. E.; OKINO, E.Y.A. Chemical composition of 36 Brazilian Amazon forest wood species. **Holzforchung**, Berlin, v.61, p.468-477, 2007.
- STEEGE, H.; PITMAN, N.C.A; PHILLIPS, O.L.; CHAVE, J.; SABATIER, D.; DUQUE, A.; MOLINO, J.; PRÉVOST, M. SPICHIGER, R. CASTELLANOS, H.; HILDEBRAND, P.; VÁSQUEZ, R. Continental-scale patterns of canopy tree composition and function across Amazonia. **Nature**, London, n.443, p.444-447, 2006.
- TRUGILHO, P.F.; LIMA, J.T.; MENDES, L.M. Influência da idade nas características físico-químicas e anatômicas da madeira de *Eucalyptus saligna*. **Revista Cerne**, Lavras, v.2 n.1, p.94-100, 1996.
- TSOUMIS, G. **Science and technology of wood: structure, properties, utilization**. New York: Van Nostrand Reinold, 1991. 494p.

Recebido em 04/02/2011

Aceito para publicação em 18/10/2011