Biochar from babassu residues: chemical characterization and thermo gravimetric analysis

C. M. B. F. Maia[(a)] *, M. Guitoku[(a)], C. C.M. Rauen[(b)], Diana Signor[(c)]
(a) Embrapa Forestry, Estrada da Ribeira km 111, Colombo, PR 83411-000, Brazil
(b) UFPR, Setor de Ciências Agrárias, Rua dos Funcionários, 1540, Curitiba, PR 80035-050, Brazil
(c) Embrapa Semi- Arid, Av. São Luís Rei de França, nº 4, Q11, São Luís, MA 65065-470, Brazil
* Corresponding author e-mail: claudia.maia@embrapa.br

Keywords: biochar, TGA, slow pyrolysis

Abstract Babassu is Brazilian palm tree considered the largest native oil resource worldwide. In this work we analyse the lignin, extractives, and holocellulose in the babassu fruit residues (endocarp) and the thermo gravimetric behaviour of the in natura residual biomass, its charcoal and its lignin. Thermogravimetric analysis showed that the removal of extractives and lignin compounds affect the thermal stability of the materials. The biochar from babassu residue is thermally stable and it does not shows functionalized groups in their structure. Besides its potential as C sequester was also demonstated fixed Carbon and thermal stability.

Introduction

The transition region between the Brazilian Amazon forest and the other surrounding biomes is characterized by a vast area (~18 million ha) of native palm trees, whose main species is the babassu (*Attalea speciosa* and *Orbignya spp*.). The babassu is a large palm, highly productive in fruits (drupe), weighing about 150 g each (Teixeira, 2002). The fruit consists of epicarp, mesocarp, endocarp and nuts. The nuts are oil rich (about 7% of fruit weight), which has an important value as biofuel. The Brazilian production of babassu kernels is estimated in 100 kt by year ((Teixeira, 2002). The babassu collecting is a socially important activity because it involves the work of women of about 450 thousand Brazilian rural families (Teixeira, 2008). It is also environmentally relevant because it produces around 93 kt in lignocellulosic wastes (Protásio et al., 2014).

The aims of this work were (a) to analyse the lignin, extractives, and holocellulose in the babassu fruit residues (endocarp) and (b) the thermo gravimetric behaviour of the *in natura* residual biomass, its charcoal and its lignin.

Experimental

Babassu endocarp was obtained after processing at local company in Maranhão, Brazil. Babassu residues were dry at 60° degree, ground and sieved to 2 mm for chemical analysis. Moisture, ash, extractives and lignin were determined. Charcoal from babassu fruit wastes were prepared using local traditional oven (slow pyrolysis). The proximate analysis of this charcoal was performed by using standard methods (ASTM D-3172–D-3175). The lignin and extractives experiments were performed according to NBR 7989 and NBR 14853, respectively standards.

The thermal degradation studies were conducted on Shimadzu DTA-50 analyser, with heating rate of 10°C.min^{-1} from room temperature to 900°C under N_2 atmosphere (20 ml.min^{-1}).

Results and Discussion

Babassu endocarp and charcoal analysis:

Chemical analysis of babassu endocarp showed extractives and lignin values lower than the one found to babassu residues (epicarp, endocarp, mesocarp all together), which were 5,59% and 31,03% respectively and a higher value to holocellulose (Protásio et al., 2014).

The charcoal showed a high value in fixed C and 5,38% of ash content, which probably reflects not only plant ashes but mineral from soil contamination.

Table 1. Chemical analysis of babassu endocarp and proximate analysis of babassu charcoal**.**

Property (%)	Endocarp	Charcoal
Extractives	4,27	-
Lignin	21,88	-
Holocellulose	71,63	-
Moisture	4,63	5,58
Ash content	2,22	5,38
Volatile matter	-	11.19
Fixed carbon	-	83,43

Thermo gravimetric analysis

According to Figure 1, the first degradation stage (up to 120°C) is related to water loss for all samples. From 200°C starts the second degradation stage, which corresponds to the decomposition of cellulose and hemicellulose molecules. This thermal event takes place simultaneously and presents maximum degradation speed close to 290ºC for *in natura* and extracted samples, with mass loss of 52.5 and 40.5 %, respectively. The third degradation stage is associated with the lignin decomposition and reaches a maximum degradation speed above 450°C (Dollimore & Wu, 1998). The behaviour of thermal degradation for *in natura* and extracted samples are similar.

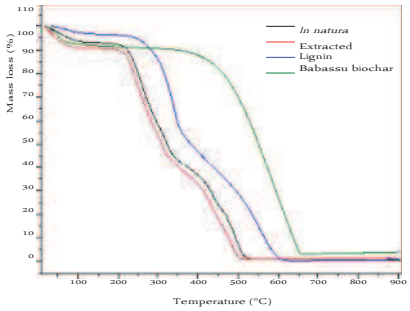

Figure 1. TG curves under nitrogen atmosphere for samples of babassu endocarp:(—) *in natura*, (—) extracted, (—) lignin and (—) Babassu biochar.

There are cellulose traces in the extracted lignin from babassu, however this material is more thermally stable than the *in natura* one and their maximum degradation speed is close to 343°C. Besides, lignin decomposes completely at higher temperatures than the *in natura* and extracted samples, with its maximum degradation rate at 590°C with 68% mass loss.

Biochar from babassu residues has different thermal degradation profile. In the absence of functionalized molecules, it has one more stage of decomposition in addition of water loss, which has the maximum degradation rate at 640°C with weight loss of 87%.

CONCLUSIONS

Besides its potential for energy, babassu endocarp showed a significant potential as biochar for C sequestration, due to their high fixed carbon and thermal stability.

The results of thermogravimetric analysis suggested that the removal of extractives and lignin compounds affect the thermal stability of the materials, probably by the increasing porosity and changes in the chemical structure thereof. The biochar from babassu residue is thermally stable and it does not shows functionalized groups in their structure.

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Acknowledgments: Authors thank to Embrapa Cocais for collecting babassu feedstock and charcoal.