Brazilian Journal of Development

Energy quality of waste from Brazil nut (*bertholletia excelsa*), in the state of Pará

Qualidade energética de resíduos da castanha-do-Brasil (*bertholletia excelsa*), no estado do Pará

Recebimento dos originais: 26/02/2019
Aceitação para publicação: 13/03/2019

Dálleth Thauanny de Oliveira Pereira
Graduação em Engenharia Florestal pela Universidade do Estado do Pará
Instituição: Universidade do Estado do Pará
Endereço: Rua Maria Angélica Dantas n°465 - Bairro Promissão I. CEP: 68628-150, Paragominas-PA, Brasil
E-mail: dalleththauanny30@hotmail.com

João Rodrigo Coimbra Nobre
Doutor em Ciência e Tecnologia da Madeira pela Universidade Federal de Lavras
Instituição: Universidade do Estado do Pará
Endereço: Universidade do Estado do Pará, Centro de Ciências Naturais e Tecnologia, Departamento de Tecnologia da Madeira. Rodovia PA-125 s, nº. Universidade Campus VI - Bairro Angelim. CEP: 68628-557, Paragominas-PA, Brasil
E-mail: rodrigonobre@uepa.br

Maria Lúcia Bianchi
Doutora em Química pela Universidade Estadual de Campinas
Instituição:Universidade Federal de Lavras
Endereço:Universidade Federal de Lavras, Departamento de Química. Campus da Universidade Federal de Lavras, DQI, Bloco I. Caixa Postal: 3037. CEP: 37200-000, Lavras-MG, Brasil
E-mail: bianchi@dqi.ufla.br

RESUMO

A quantidade de resíduos que são descartados da castanha-do-Brasil gerados na extração de um fruto é de 1,6 kg de casca e 2 kg de ouriço. Uma alternativa de utilização para esses resíduos é a produção de energia. Logo, o objetivo do presente trabalho é analisar o poder calorífico da casca da castanha-do-Brasil e o rendimento do carvão produzido a partir desse resíduo, afim de conhecer o potencial energético do mesmo. Os resíduos da castanha foram coletados no município de Castanhal-PA. Parte do material foi triturado e peneirado com granulometria de 40, 60, 100, 200 e 270 mesh e acondicionados em sala de climatização para a realização das análises e a parte in natura foi carbonizada em forno tipo Mufla com temperatura de 450º por 60 minutos. O rendimento gravimétrico foi determinado pela massa do carvão seco dividido pela massa da madeira seca, multiplicado por 100 e o poder calorífico superior (PCS) determinado segundo a norma ABNT NBR 8633/84 e conforme o manual do calorímetro PARR 1201, além da determinação do poder calorífico inferior (PCI) e poder calorífico líquido (PCL). O resultado de rendimento gravimétrico da carbonização encontrado para os resíduos de *Bertholletiaexcelsa* foi de 41,67%. O poder calorífico superior para o carvão foi de 7092,5 kcal/kg, para poder calorífico inferior, 6905,6 kcal/kg e 6877,4 kcal/kg para poder calorífico líquido. Esses resultados estão relacionados a composição química e elementar da carbonização, determinando assim o potencial dos resíduos para serem utilizados com fins energéticos.

Palavras-Chave: biomassa; carvão vegetal; rendimento; poder calorífico.

ABSTRACT

The amount of residues that are discarded from Brazil nuts generated in the extraction of a fruit is 1.6 kg of bark and 2 kg of hedgehog. An alternative use for such waste is the production of energy. Therefore, the objective of this work was to evaluate the energy properties of Brazil nut shell, as well as the gravimetric yield of charcoal produced from this residue, in order to know its energy potential. Chestnut residues were collected in the municipality of Castanhal-PA. The gravimetric yield was determined by the mass of the dry coal divided by the mass of the dry biomass, multiplied by 100. The in natura material was charred in a Mufla type oven with a temperature of 450º for 60 minutes. The upper calorific power (UCP) was determined according to the standard ABNT NBR 8633/84 and according to the manual of the calorimeter PARR 1201, besides the determination of the lower calorific power (LCP) and the net calorific power (NCP). The result of the gravimetric yield of the carbonization found for the residues of *Bertholletiaexcelsa* was 41.67%. The upper calorific power for coal was 7092.5 kcal /kg, for lower calorific power, 6905.6 kcal /kg and 6877.4 kcal /kg for net calorific power. These results are related to the chemical and elemental composition of the carbonization, thus determining the potential of the waste to be used for energy purposes.

Keywords: biomass; charcoal; yield; calorific power.

1 INTRODUCTION

The use of forest biomass as an energy input, in its different forms of exploitation, has aroused interest in several countries due to its renewable potential, as well as to generate opportunities for work in the energy production process and the creation of new markets for forest residues (SANTIAGO, 2013).

One of the most important species of the Amazon is Brazil nut (*Bertholletiaexcelsa*), native fruit of chestnut-tree, the tree of the family Lecythidaceae, also called Pará nut, black-brown chestnut, tocari, tururi, cari, juviá, among others. Large tree, measuring up to60 m in height, with a diameter of 100 to 180 cm. Brazil nut is rich in oil, consisting of 60 to 70% of lipids and 15 to 20% of proteins, as well as other constituents (GONÇALVES, 2013). Each Brazilian chestnut fruit collected has, on average, 1,6 kg of residual (residual biomass), including the bark of the raw chestnut, or, for every 1 kg of chestnut collected, one has to generation of 2 kg of hedgehog, which can be harnessed (OLIVEIRA e LOBO, 2002). These are lignified structures with complex composition,with potential for use in handicrafts and energy (FAUSTINO et al., 2014).

In 2010, the production of almonds of Brazil nut was 40,357 tons. Thus, it is estimated that the total number of barks and hedgehogs generated in that year was 56,500 tonnes(OLIVEIRA e LOBO, 2002; FERREIRA, 2009).

Therefore, the objective of this work was to evaluate the energy properties of Brazil nut shell, as well as the gravimetric yield of charcoal produced from this residue, in order to know its energy potential.

2 METHODOLOGY

Brazil nut residue (*Bertholletiaexcelsa*) was collected in the municipality of Castanhal, located in the northeast region of the state of Pará. Some of the in natura material was stored for later carbonization. Another part was packed in sealed and identified plastic bags.

For the production of charcoal, the in natura material was used, with a mean humidity of 12%. The charcoal was produced in a muffle furnace adapted to this function, with a heating rate of 1.67 °C / min, at a temperature of 450 °C, with a residence time of 60 minutes at the final temperature. The cooling took place naturally and gradually after the kiln reached the carbonization conditions. The carbonization conditions and parameters were based on the methodology described by Nobre (2013), in which residues of Amazonian species were used to produce charcoal and activated charcoal.

In order to obtain the gravimetric yield of the carbonization, the formula used was:$\mathrm{YGc}(\%) = \left(\frac{\mathrm{MCd}}{\mathrm{MBd}}\right) * 100$, where MCd is the mass of dry coal (g) and MBd is the mass of the dry biomass (g) before carbonization.

After charring, the charcoal was ground and sieved in a set of sieves with a grain size of 40, 60, 100, 200 and 270 mesh for the analysis. The granulometricallyclassified materials were conditioned in an air conditioning room, with a temperature of 20 ± 2 °C and humidity of 65 ± 3%, until reaching a constant mass, with a mean humidity of 12%.

The determination of the upper calorific power (UCP) in kcal/kg was performed according to the ABNT standard NBR 8633/84 and according to the manual of the calorimeter PARR 1201, using a digital calorimeter, model IKA C-200. A formula was also used to estimate the lower calorific power (LCP) and the net calorific power (NCP) from the UCP results, the hydrogen content and the moisture content of the material.

In order to determine the Lower Calorific Power (LCP), the following equation was used: $LCP\left(\frac{kcal}{kg}\right) = UCP - 6*9*H$, where H is the hydrogen content (%) and to estimate the Net Calorific Power (NCP) was used the equation: $NCP\left(\frac{kcal}{kg}\right) = \frac{[LCP-(6*U)]}{(100+U)} * 100$,where U is the humidity (%). The values of moisture (4.93%) and hydrogen content (3.46%) of the coal were according to the results obtained by Leandro et al. (2018).

3 RESULTS AND DISCUSSION

The results of the gravimetric yield of the coal obtained at a temperature of 450ºC of the residues of *Bertholletiaexcelsa* will be presented in table 1.

Table 1. Gravimetric yield of the carbonization at 450ºC of the residues of *Bertholletia excelsa* (Brazil nut). Source: Authors (2018)

Temperature (°C)	**Gravimetric yield of the carbonization**	
450°	**Average** (%)	41,67
	SD (%)*	1,20
	CV**	2,88

*SD: standard deviation; CV: coefficient of variation

The gravimetric yield found is 41.67%. The high yield can be attributed to the chemical composition of the bark, since it is rich in lignin and carbon. According to Leandro et al. (2018), the values found were 55,76% lignin and 72,50% carbon. These components confer greater resistance to thermal degradation of the material during the carbonization process.

Carmona et al. (2017), found a value of gravimetric yield in the charcoal of Brazil nut of 44.52%, showing a small variation of the value shown in table 1, showing a great potential of use for carbonization.

Vilas Boas et al. (2010) studying the carbonization of macaúba (*Acrocomiaaculeata*) endocarp, in muffle with temperatures ranging from 450 °C to 650 °C, found a 35,13% average gravimetric charcoal yield. Silva et al. (1986) compared the gravimetric yield of eucalyptus wood charcoal, babassu and macaúba endocarp obtained from muffle carbonization, with temperatures varying from 300 ° C to 700 ° C. In this study, the authors found values of 31,97%, 33,49% and 39,37% for eucalyptus, babassu and macaúba, respectively. Thus, it is observed that the values of gravimetric yield found in this work are above those found for other residual biomasses. The mean values obtained for the results of upper, lower and liquid calorific power (kcal/kg) from the charcoal of *Bertholletiaexcelsa* are shown in table 2.

Table 2. Mean values, standard deviation and coefficient of variation of the upper calorific power (UCP), lower calorific power (LCP) and net calorific power (NCP) of *Bertholletiaexcelsa* (Brazil nut).

	Calorific power(kcal/Kg)			
		UCP	LCP	NCP
Charcoal	**Average**	7092,5	6905,6	6877,4
	SD	87,72	87,72	87,72
	CV	0,012	0,012	0,012

Source: Authors (2018)
SD: standard deviation; CV: coefficient of variation

The average results found for the upper calorific powerwere 7092,5 kcal/kg, while the lower calorific powerwas 6905,6 kcal/kg and 6877,4 kcal/kg for the net calorific power of charcoal. The determination of calorific power is very important for the energy use of the biomass because it indicates the potential capacity of a material to give off heat. The high value of the upper calorific power (7092,5 kcal/kg) comes from the chemical and elemental composition of the carbonization of the biomass. According to Leandro et al (2018), the percentage of lignin present in Brazil nut is 55.76% and 72.50% carbon, in addition to the low ash content (1.76%). considered to be more suitable for the production of activated carbon.

Studies of Doat and Petroff (1975) found in charcoal obtained from tropical woods aupper calorific power between 7000 and 7500 kcal/kg. The upper calorific power of the coal studied in this work was in this range.

Vilas Boas et al. (2010) found average values of 4,996.18 kcal/kg for macaúba (*Acrocomiaaculeata*) in natura and 7,819.29 kcal/kg for carbonized biomass. It is noteworthy that the values found for macaúba are slightly higher than those observed for Brazil nut.

Nogueira et al. (2014), found the upper calorific power of Brazil nut urchin in natura of 4,793.02 kcal/kg and 7,252.98 kcal/kg for charcoal. It is observed a value slightly higher than that quoted in this work, demonstrating that both the hedgehog and the shell of the chestnut present high capacity in the generation of energy, due to the high content of lignin and carbon present in its chemical composition.

Vale et al. (2011) obtained the result of useful or net calorific power (NCP) for *Jatrophacurcas* processed into charcoal, of 6,233 kcal/kg, lower result compared to the coal of the chestnut shell (6877,4 kcal/kg).

4 CONCLUSIONS

Residual biomass for energy production has high potential due to its high heat capacity.

The charcoal of this biomass presented high gravimetric yield, being suitable for use in direct combustion, activated carbon and biochar.

In addition to the energy potential, biomass has a large participation in the economic activity of Amazonian families.

ACKNOWLEDGEMENT

To UEPA, University of the State of Pará, for the support. To the Federal University of Lavras and the Post-Graduate Program in Science and Technology of Madeira, bythe analyzes. To the CITM, Madeira Science, Innovation and Technology research group in the Amazon, for the orientation of this work.

REFERENCES

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS – ABNT. **NBR 8633/84**. Determinação do poder calorífico superior. 13p. 1984.

CARMONA, I.N.; SAMPAIO, J.S.; ANDRADE, F.W.C.; JÚNIOR, C.D.C.; JUNIOR, S.M.O.M.; MOREIRA, L.S.; MOUTINHO, V.H.P. Potencial energético da biomassa e carvão vegetal de resíduos de Castanha-do-pará (*Bertholletia excelsa*Bonpl.). CONGRESSO BRASILEIRO DE CIÊNCIA E TECNOLOGIA DA MADEIRA, 3, 2017. **Resumos**. Florianópolis, 2017.

DOAT, J.; PETROFF, G. La carbonizationdes bois tropicaux. **RevueetForetsdesTropíques**. Nogent-sur-Harne, 55-72, 1975.

FAUSTINO, C. de L.; WADT, L. de O. Resistência mecânica do pericarpo de frutos de *Bertholletia excelsa*Bonpl. (Lecythidaceae). **Ciência da Madeira**, Pelotas, v. 5, n. 1, p. 25-33, 2014.

FERREIRA, B. **Pesquisadores fazem tijolo com cascas e caroços**. Globo Rural, 17 jun. 2009. Disponível em: <http://revistagloborural.globo. com/GloboRural/0,6993,EEC1701490-1932,00.html>. Acesso em: 20 de junho de 2018, 14:15:22.

GONÇALVES, J. D. **Equilíbrio líquido-líquido dos sistemas biodiesel de castanha do brasil + metanol + (glicerina ou água): determinação experimental e modelagem termodinâmica**. 2013. 121p. Dissertação (Mestrado em Engenharia Química) – Universidade Federal do Pará, Belém, 2013.

LEANDRO, R.I.M.; ABREU, J.J.C.; MARTINS, C.S.; SANTOS, I.S.; BIANCHI, M.L.; NOBRE, J.R.C. Determinação das características elementares, químicas e de energia dos resíduos da castanha do Brasil (Bertholletia excelsa) no estado do Pará. In: CONFERÊNCIA DE BIOMASSA E BIOENERGIA, 2018. **Resumos**. Sorocaba, 10 a 12 de abril de 2018.

NOBRE, J. R. C. **Produção e qualidade do carvão ativado de resíduos de madeira de espécies do estado do Pará**. 2013. 115p. Dissertação (Mestrado em Ciência e Tecnologia da Madeira) - Universidade Federal de Lavras, Lavras, 2013.

NOGUEIRA, R.M; RUFFATO, S.; CARNEIRO, J.S; PIRES, E.M.; ÁLVARES, V.S. Avaliação da carbonização do ouriço da castanha-do-Brasil em forno tipo tambor.**ScientificElectronicArchives**, v. 6, p. 7-17, 2014.

OLIVEIRA, J.M.C.; LOBO, P.C. Avaliação do potencial energético de resíduos de biomassa amazônica. In: Encontro de Energia no Meio Rural, 4, 2002, Campinas. **Anais**. Campinas, 2002.

SANTIAGO, F. L. S. **Aproveitamento de resíduos florestais de *Eucalyptus spp*. na indústria de fabricação de celulose para geração de energia térmica e elétrica**. 2013.

109 p. Tese (Doutorado em Agronomia) – Faculdade de Ciências Agronômicas, Universidade Estadual de São Paulo, Botucatu, 2013.

SILVA, J.C.; BARRICHELO, L.E.G.; BRITO, J.O. Endocarpos de babaçu e de macaúba comparados a madeira de *Eucalyptusgrandis* para a produção de carvão vegetal. **IPEF**, n.34, p.31-34. 1986.

VALE, A.T.; MENDES, R.M.; AMORIM, M.R.S.; DANTAS, V.F.S. Potencial energético da biomassa e carvão vegetal do epicarpo e da torta de pinhão manso (*Jatrophacurcas*). **Revista Cerne**, Lavras, v. 17, n. 2, p. 267-273, abr./jun. 2011.

VILAS BOAS, M.A.; CARNEIRO, A.C.O.; VITAL, B.R.; CARVALHO, A.M.L.; MARTINS, M.A. Efeito da temperatura de carbonização e dos resíduos de macaúba na produção de carvão vegetal. **Scientia Forestalis**. V.38, n.87, p. 481-490. 2010.