ENERGY COGENERATION IN THE AMAZON THROUGH THE USE OF AÇAÍ WASTE - IN SILICO STUDY USING EMSO

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ABSTRACT

Currently, it has been extremely important to study the açaí production chain with a view to the sustainable destination of the waste generated. Given this scenario, the use of in silico tools would solve part of the problems and provide opportunities for implementing productive solutions on site. According to the Food and Agriculture Organization of the United Nations, Brazil has 1.3 billion tons of waste annually, with 1/3 of food intended for consumption being wasted due to the lack of viable recycling strategies. On the other hand, waste recovery is sustainable, economical, cheap, rich in organic materials and an abundant resource. Thus, it can be considered one of the most efficient alternatives for recycling and, consequently, for the production of products with high added value. Traditional waste disposal alternatives involve landfills, composting, extraction of inulin from açaí and animal feed. Improving and adding to these alternatives the generation of electrical energy via cogeneration of biomass waste would solve the major problem of tons of açaí waste produced and would favor the development of local Amazonian communities and regional agribusiness.

Keywords: Production chain. Amazon region. In silico simulation. Electrical energy. EMSO.

1 INTRODUCTION

Electricity generation in remote regions, such as the Amazon, is challenging due to the lack of conventional energy infrastructure, resulting in significant dependence on non-renewable and polluting sources. However, the Amazon region is rich in natural resources, including açaí, a widely consumed fruit that generates a considerable amount of waste during processing activities [1]. Converting this waste into a sustainable energy source is an innovative goal.

The global objective of sustainable development requires the adoption of renewable energy resources in energy generation. Biomass is an unlimited renewable energy resource with almost infinite raw material possibilities [2]. Biomass residues are suitable supplies for generating electrical energy, since in addition to generating useful energy, they also contribute to reducing waste disposal.

An estimate of Brazilian production indicates that 221 thousand tons of açaí were produced in 2018, where 85-95% of the total mass of the fruit is discarded after processing, with the seed being the main discard material [3].

A study carried out identified some ways of disposing of açaí seeds adopted by pickers in the municipalities of Macapá and Santana. The main way is to pay for the seeds to be collected from the churns, estimating a total of 15,875 kg/day. Furthermore, 6,055 kg/day are simply thrown away, 1,185 kg/day are left for collection in front of establishments, and 1,340 kg/day are donated. In total, approximately 24,455 kg of açaí seeds are discarded daily in the two municipalities. Of this total, 11,580 kg/day are sent to brickworks, 4,050 kg/day are thrown into lakes, 3,085 kg/day go to open dumps or controlled landfills, 1,600 kg are used as fertilizer and 4,140 kg/day have an unknown destination [4].

The motto "From waste to resource" reflects the essence of this study, which seeks to utilize açaí waste, often improperly discarded, and transform it into a valuable resource for electricity generation. This would not only reduce raw material waste but also provide remote Amazonian communities with access to a reliable and sustainable energy source.

Among the different forms of electrical energy production through biomass, cogeneration has proven to be quite efficient. In Brazil, cogeneration has been widely used to generate electrical energy through the combustion of sugarcane bagasse. Here, in this study, Amazonian waste was used, such as açaí seeds, widely discarded in the region, to optimize electricity production processes. As a priority, an in silico study was carried out in search of the ideal parameters for cogeneration of electrical energy.

In silico exploration is a procedure carried out on a computer or through computer simulation. Simulation is an efficient and inexpensive way to study and analyze new chemical process scenarios. Thus, the objective of this study was to develop and improve the entire process of cogeneration of electrical energy via consumption of açaí waste, through computer simulation using the EMSO software.

2 MATERIAL & METHODS

The methodology involves in silico modeling of the gasification process of açaí waste using the EMSO software. This includes the definition of input parameters, simulation of chemical reactions, thermodynamic analysis and estimation of gasification efficiency. Real data on açaí residues are incorporated so that the simulation is as accurate as possible. The results obtained will be compared with technical and economic feasibility criteria to determine the effectiveness of the process.

The software chosen was EMSO (Environment for Modeling, Simulation and Optimization). This software was created based on the work of SOARES (2003) in a consortium with national petrochemical companies to simulate stationary and transient processes in the industry, being free for academic purposes [5].

The simulated cogeneration system consists of two pumps that inject liquid water into the boiler at 65 bar. In the modeling, a dry air supply stream was inserted, composed of 79% molar N2 and 21% O2, in addition to a combustion gas outlet stream, and a variable that considers 16.5% excess oxygen.

The simulated model consists of three inputs: Waste, Air and Water, in addition to two outputs: Steam and Gases. The reaction equations that were considered for the mathematical modeling of the process are presented below:

Complete combustion:

$$Cellulose\ (C_6H_{10}O_5) + 6O_2 \rightarrow 5H_2O + 6CO_2 \tag{1}$$

$$Hemicellulose\ (C_5H_8O_4) + 5O_2 \rightarrow 4H_2O + 5CO_2 \tag{2}$$

$$Lignin\ (C_{7.3}H_{13.9}O_{1.3}) + 10.125O_2 \rightarrow 6.95H_2O + 7.3CO_2 \tag{3}$$

Incomplete combustion:

$$Cellulose\ (C_6H_{10}O_5) + 3O_2 \rightarrow 5H_2O + 6CO \tag{4}$$

$$Hemicellulose\ (C_5H_8O_4) + 2.5O_2 \rightarrow 4H_2O + 5CO \tag{5}$$

$$Lignin\ (C_{7.3}H_{13.9}O_{1.3}) + 6.475O_2 \rightarrow 6.95H_2O + 7.3CO \tag{6}$$

The generation of NO_x was not considered due to its low generation. Based on the reactions of complete combustion, incomplete combustion and the balance of each component, the following mass balances were constructed for modeling the boiler, in which:

$$f = molar\ ratio\ of\ {}^{CO}/_{CO_2}\ output = 0.0202 \tag{7}$$

3 RESULTS & DISCUSSION

The results obtained through in silico simulation in the EMSO software of the açaí waste cogeneration process indicate that this approach has the potential to be a viable energy source for remote regions of the Amazon. The efficiency of cogeneration proved promising, generating substantial production of thermal energy and electrical energy from açaí waste. Considering the region's energy challenges, the transformation of waste into energy resources represents an environmentally beneficial and economically advantageous solution. This could reduce dependence on fossil fuels, reduce environmental impact and improve the quality of life of local communities. Furthermore, the use of açaí waste could promote a circular economy, reducing waste and creating opportunities to generate income.

4 CONCLUSION

The cogeneration of açaí waste has proven to be a promising alternative for generating electricity in remote regions of the Amazon. Furthermore, there is an adequate disposal of waste that was previously inappropriately disposed of in the environment. This approach can not only contribute to the diversification of the energy matrix and the reduction of the carbon footprint, but it also represents an opportunity to promote sustainable development in local communities.

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