POTENTIAL OF BIOGAS PRODUCTION FROM ANAEROBIC CO-DIGESTION OF LICURI FIBER AND SEWAGE SLUDGE

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ABSTRACT

Anaerobic digestion faces challenges during the hydrolysis of lignocellulosic biomass. These residues are composed of cellulose, hemicellulose and lignin, forming a complex structure that makes biodigestion difficult. In this sense, anaerobic co-digestion emerges as an alternative to increase the efficiency of this process, optimizing the production of bioenergy, in addition to assisting in waste management. This work investigated the production of biogas from the anaerobic co-digestion (AnCoD) of licuri fiber (LF) and sewage sludge (SS). The analysis was carried out in glass bioreactors with a working volume of 80mL, using different proportions of LF and SS and an equine feces solution as inoculum. The results indicated that the accumulated production of biogas was higher in bioreactors with 50%LF-50%SS, standing out on the 8th day. In contrast, samples with 6%LF-94%SS and 12.5%LF-87.5%SS started production in the first few days, but presented a lower volume. This study suggests that the co-digestion of licuri fibers and sewage sludge is a viable route for biogas production, promoting efficient waste management and reducing the carbon footprint.

Keywords: Licuri. Sewage sludge. Co-digestion. Lignocellulosic waste.

1 INTRODUCTION

The global community's concern about greenhouse gas (GHG) emissions has driven the search for energy sources free of fossil fuels. In this context, anaerobic digestion (AD) stands out as a promising technology for the production of bioenergy, such as biogas and biomethane, favoring the mitigation of climate change through the decarbonization of the energy sector and the use of different types of waste.

The abundance of lignocellulosic residues made this biomass attractive for the biofuels sector. However, its complex structure composed of cellulose, hemicellulose and lignin, which are important sources of carbon, oxygen and hydrogen, slows down the degradation process[1].

Syagrus coronata (Martius) Beccari, also known as "Licuri" or "Ouricuri", is an evergreen palm tree native to Brazil. This species is an important source of income for semi-arid communities, in addition to being a food resource for several wildlife species. Its fruits are used in food, for therapeutic purposes, in the production of cosmetics and biofuels such as biodiesel. The mesocarp (fibers) and endocarp (hard shell) constitute the lignocellulosic residue from the use of almonds, which are normally discarded[2].

Due to the recalcitrant nature of the lignin present in this residue, hydrolysis presents itself as a limiting step in AD, delaying the extraction of cellulose and hemicellulose. Therefore, pre-treatments that facilitate the breakdown of lignin are crucial steps to maximize biogas production. In this sense, anaerobic co-digestion (AnCoD) of lignocellulosic waste with sewage sludge inoculated with feces is being evaluated due to advantages such as increasing the microbial community, balancing the C:N ratio, adjusting pH, total solids (TS) and supplying of micronutrients, which are essential parameters for the efficient production of this biofuel[3]. Therefore, this work presents a viable route for simultaneously processing licuri fiber and sewage sludge to generate biogas.

2 MATERIAL & METHODS

2.1 Substrates and Inoculum

Licuri fruits were collected in Guirra farm, located in Senhor do Bonfim, Bahia, Brazil (10°23′17.8"S. 40°12′12.2"W). The fruits were washed with water and peeled. The licuri fibers (94.21% ST) were crushed and refrigerated (4 ºC) for subsequent use. Sewage sludge (pH 7.1±0.1; 0.64% TS) was collected at the sewage treatment plant of Companhia de Saneamento de Sergipe located in the city of Aracaju, SE, Brazil (10°57′04.8″S. 37°04′39.1″W). Horse feces (inoculum) (pH 6.3 ±0.1; 29.97% ST) were collected at the military police cavalry, located in the city of Aracaju, Sergipe, Brazil (10°52'50.7"S. 37 °03'11.0"W). The bacterial inoculum solution (8% ST) used in the experiments was prepared from fresh horse feces and tap water 3. The inoculum solution and the effluent were stored separately in a sterilized and refrigerated plastic container (4 ºC) to preserve your characteristics.

2.2 Experimental setup

The studies were carried out in glass bioreactors (125mL) with a working volume of 80mL for 21 days. The biogas production potential was evaluated using different proportions of licuri fiber (LF) and sewage sludge (SS): 6%LF-94%SS; 12.5%LF-87.5%SS; 25%LF-75%SS; 50%LF-50%SS; 50%LF-50%Water, 100%SS, using horse feces solution as inoculum (10% of the working volume). The bioreactors were closed with a rubber lid and oxygen was removed by purging for approximately 2 minutes with 99.99% nitrogen gas. Finally, the bioreactors were inserted into a stirring bath (100 rpm) at a temperature of 37 ± 1ºC.

3 RESULTS & DISCUSSION

3.1 Biogas production via anaerobic Codigestion (AnCoD)

The daily biogas production values for the AnCoD experiments are shown in Figure 1. Biogas production in bioreactors with 25% LF-75% SS and 50% LF-50% SS stood out between the 7th and 8th day of digestion. In contrast, samples with 6%LF-94%SS and 12.5%LF-87.5%SS showed an increase in the first days of the process. This behavior is attributed to the rapid degradation of organic matter, which may have caused the accumulation of volatile fatty acids (VFA) in the reaction[3]. Although they produced less biogas at the beginning, the samples 25% LF-75% SS and 50% LF-50% SS showed greater production at the beginning of the second week, suggesting that methanogenesis was carried out successfully. The horse feces solution (inoculum) may have stimulated biomass hydrolysis through groups of microorganisms that helped break down lignin. Furthermore, the neutral pH of SS favored the development of methanogenic archaea, highlighting the synergistic effect of AnCoD.

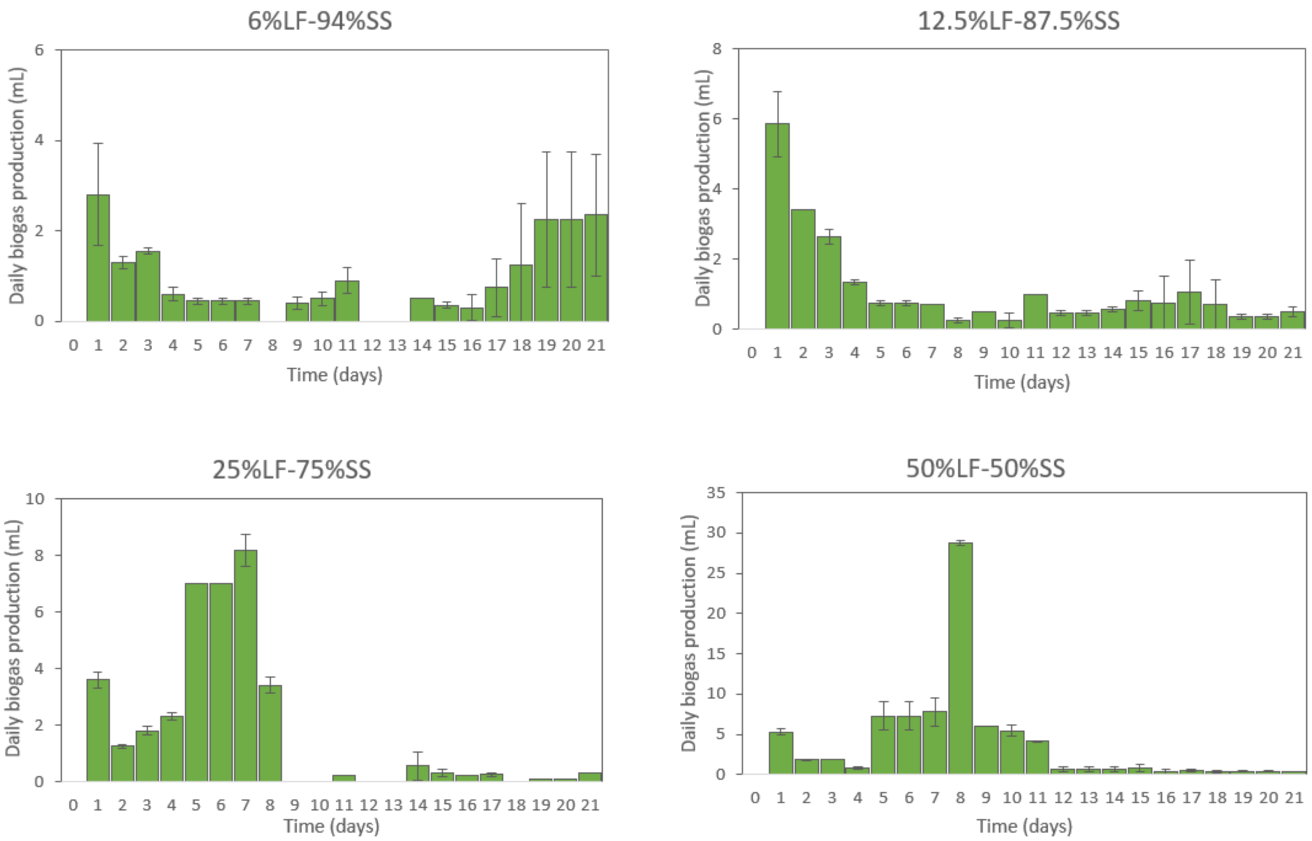

Figure 1 Daily biogas production from the AnCoD process.

The accumulated biogas production values for the AnCoD and AD experiments are presented in Table 1. The accumulated production of the samples 6%LF-94%SS, 12.5%LF-87.5%SS, 25%LF-75%SS, 50 %LF-50%SS was 19.4mL, 23.4mL, 36.55mL and 81.4mL, respectively. Greater biogas production was observed as the proportion of LF increased in the mixture. The increase in the proportion of biomass may have contributed to the increase in the C/N ratio and dilution of toxic SS compounds. On the other hand, a reduced production of biogas (13.95mL) was observed in bioreactors containing 100%SS, which can be explained by the little organic matter present in the SS used (0.43%VS).

Table 1 Accumulated biogas production from the AD and AnCoD process.

Sample	Cumulative biogas production (mL)
6%LF-94%SS	19.4
12.5%LF-87.5%SS	23.4
25%LF-75%SS	36.55
50%LF-50%SS	81.4
50%LF-50%Water	38.15
100%SS	13.95

In another set of experiments, the best proportion of LF (50%) was maintained and SS was replaced with water (to adjust the moisture content) in order to evaluate the influence of SS on AnCoD. When the results of AD (50%LF-50%Water) and AnCoD (50%LF-50%SS) were evaluated, it was observed that biogas production increased by approximately 113% after AnCoD of waste. These results corroborate data from the literature where SS was used in the co-digestion of different lignocellulosic residues, such as pumpkin seed [4], rice straw [5] and okra residue[3].

4 CONCLUSION

The results revealed a promising potential for the production of biogas from the anaerobic co-digestion (AnCoD) of licuri fibers and sewage sludge. The appropriate choice of inoculum and proportions of substrates for AnCoD favored the balance of the C/N ratio, microbial diversity and the consequent increase in the biodegradability of lignocellulose. Therefore, this study suggests a new method for using licuri fibers, promoting efficient waste management and the generation of renewable energy.

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