OBTAING SUGARS FROM CORN RESIDUES PRODUCED IN THE FAR NORTH OF THE AMAZON

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ABSTRACT

Faced with the increase in the demand for energy and the scarcity of certain natural resources, finding ways to avoid environmental imbalances has become an important focus in research. In Roraima, corn production is increasing, and its processing generates tons of husks and cobs, rich in xylose and glucose. In this context, lignocellulosic biomass is presented as a sustainable proposal for the production of fermentable sugars. This research aimed to obtain fermentable sugars from corn residues and analyze the conditions used in the acid and enzymatic hydrolysis process. The residues were pretreated, and the fermentable sugars were quantified using 3,5-dinitrosalicylic acid, then identified with near-infrared spectroscopy. In the enzymatic process, the sugar concentration obtained was 72.08 g L^{-1} for the husks and 69.94 g L^{-1} for the cobs. In the acid hydrolysis, 18.18 g L^{-1} was obtained for the husks and 19.20 g L^{-1} for the cobs, with xylose and glucose identified as the main sugars. These results suggest that these residues can serve as sustainable alternatives for the production of fermentable sugars in the northern region of Brazil, given the growth in corn plantations. This sustainable approach aligns with efforts to address energy demands while mitigating environmental impacts.

Keywords: Amazon. Biomass. Development. Husks. *Zea mays*.

1 INTRODUCTION

The constant exploitation of fossil fuels has caused socio-environmental and economic problems, highlighting the need for clean and sustainable energy. In many countries, most of the energy consumed comes from burning fossil fuels, which are non-renewable resources and major contributors to global warming. To meet the growing energy demand, it is crucial to develop efficient and environmentally friendly alternatives, reducing dependence on these fuels and their price instability.
Research into new sources of renewable raw materials and alternative technologies is essential for a low-carbon future. Renewable energy sources, such as biomass, stand out as potential choices for producing fermentable sugars, particularly due to the availability of lignocellulosic agricultural residues, such as corn.
Although biomass is a promising renewable energy source, concerns about the sustainability of its large-scale use persist, particularly regarding food security and price instability. In northern Brazil, the state of Roraima has shown significant growth in corn production, offering an alternative for generating clean energy from residues rich in fermentable sugars.
Despite the lack of specific studies on fermentable sugar production from corn residues in Roraima, this research aims to produce these sugars using acid and enzymatic hydrolysis of corn residues, evaluating their potential and optimizing the production process. This study aligns with six of the seventeen sustainable development goals (SDGs), promoting the value generation from corn waste, creating sustainable energy alternatives, and mitigating the generation of polluting waste.

2 MATERIAL & METHODS

Acid and enzymatic hydrolysis of corn residues

Acid hydrolysis was conducted using sulfuric acid (H_2SO_4) at concentrations of 1%, 2%, and 3%. For enzymatic hydrolysis, the commercial enzyme Spring Alpha Amylase, produced by *Aspergillus oryzae*, was used at the same proportions. Both hydrolyses were performed separately in 250 mL Erlenmeyer flasks containing hydrated powder at concentrations of 3%, 5%, and 10% for both husks and cobs. The mixtures were agitated at 120 rpm at temperatures of 30, 40, and 50 ºC for up to 36 hours. Aliquots of 2 mL were taken every 6 hours to evaluate the optimal conditions for fermentable sugar production. This procedure was applied to both husks and cobs under the same conditions. The study assessed the best conditions for producing total reducing sugars (TRSs), including reaction time, temperature, acid/enzyme concentration, substrate concentration, and type of substrate. All analyses were performed in triplicate.

Quantification of the total reducing sugars (TRSs) of the hydrolysates

The TRSs were quantified using the 3,5–dinitro-salicylic acid (DNS) method [1]. Therefore, 1 mL of each sample was diluted 10 times and after this dilution, 20 µL of the diluted sample was collected, adding 180 µL of distilled water and 300 µL of DNS solution. Then, the samples were heated for 5 minutes at 100 °C, and distilled water was added, obtaining a final volume of 2 mL. The solution was read in a spectrophotometer (Shimadzu UV 1800) at 540 nm and the concentration of the TRSs was calculated by means of a xylose standard curve. The same method was applied to quantify the glucose.

Near-infrared (NIR) identification of glucose and xylose

The absorbance spectra of the hydrolyzed samples of the corn residues were obtained using a spectrophotometer (MB 3600, ABB Bomem) equipped with a diffuse reflectance accessory. An aliquot of approximately 2 mL of the standard solution (glucose and xylose) was placed in glass cuvettes for analysis in the spectrophotometer, then the samples of the hydrolyzed corn residues. The mean spectrum of 30 readings was obtained at a resolution of 8 cm^{-1} in order to ensure reproducibility and consistency of data in each analysis. All the spectra used in this work were obtained at a temperature of 26 ± 2 °C and, in all the infrared analyses, the integrity of the sample was preserved [2].

Statistical analysis

To determine the effect of variables such as hydrolysis reaction time, temperature, acid/enzyme concentration, substrate concentration, and substrate type on the response variable (total reducing sugars - TRSs), a generalized additive model (GAM) was used with 711 data points. The model estimated relationships based on the study data, using a logarithmic link function and gamma distribution for the residuals, suitable for positive continuous concentration data. Each predictor had a maximum of three degrees of freedom, allowing for cubic curves. The model also considered interactions between substrate type and other variables. If no interactions were found (P > 0.05), they were removed, and the model was re-estimated to test independent effects. Partial graphs were used to visualize relationships, showing the dependent variable's relationship with each predictor while controlling for other variables. All analyses were conducted using R 4.2.2.

3 RESULTS & DISCUSSION

Analysis of the variables of the acid and enzymatic hydrolysis

The variables time and substrate concentration (for husks) demonstrated more complexity, with degrees of freedom of 1.82 and 1.98 respectively, compared to other variables with a degree of freedom of 1. Significant interactions had a P-value <0.001, indicating they were not random. Temperature and acid concentration did not affect TRS production (Table 1). The maximum TRS values were 19.20 g L-1 for cobs and 18.18 g L-1 for husks.The found results and discussion must be presented in this topic.

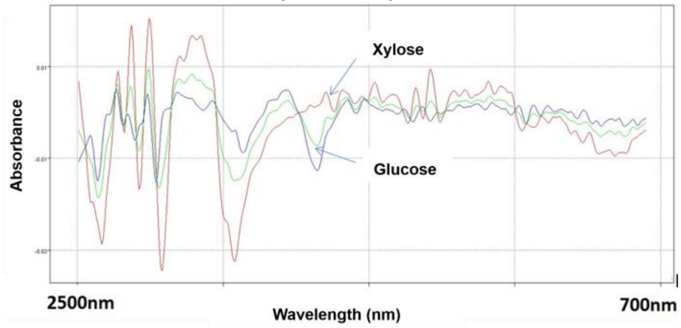
Variables	Degrees of freedom	*F*	*P*
Type of substrate	1	10.62	**0.001**
Time	1.82	13.99	**<0.001**
Temperature	1	0.007	0.936
Conc. of acid	1	0.21	0.645
Substrate|Husks	1.98	26.92	**<0.001**
Substrate|Cobs	1	34.39	**<0.001**
Conc. of Enzyme|Husks	1	81.00	**<0.001**
Conc. of Enzyme|Cobs	1	173.10	**<0.001**

Table 1 – Influence of the variables substrate type, time, temperature, concentration of substrate, acid and enzyme on total reducing sugars. The results show evidence for interactions between concentration and substrate type (F = 15.11, $P < 0.001$), and between enzyme concentration and substrate type ($F = 8.54$, $P < 0.001$).

Identification of fermentable sugars using near-infrared (NIR) spectroscopy

This study found that using dilute sulfuric acid as a catalyst for acid hydrolysis of corn residues did not successfully identify sugars, likely due to by-products formed during pentose and hexose dehydration. Figure 1 illustrates spectra after processing with a moving average, baseline correction, and first derivative. Absorption peaks in the NIR region for xylose and glucose were similar due to their structural resemblance, but NIR spectroscopy showed potential for identifying these fermentable sugars. Cob samples exhibited a spectral profile more akin to glucose, suggesting higher glucose concentrations compared to xylose. Differences in O-H group numbers and hydrogen bonding likely differentiate glucose and xylose absorption magnitudes. The study demonstrated promising results in NIR-based identification of plant components, particularly fermentable sugars in corn residues.

Figure 1 – Identification via NIR spectra of glucose (green color), xylose (red color) after enzymatic hydrolysis of the corncob (blue color).



Via the results, it is possible to identify the fermentable sugars obtained from corn husks and cobs, especially xylose and glucose. The significant amount of these sugars that are available and the promising yield from this biomass, depending on the pretreatment employed, should be of great interest to the bioethanol industry [3].

4 CONCLUSION

The study explored low-cost methods combined with hydrolysis to utilize corn husks and cobs for obtaining fermentable sugars, highlighting their potential to address environmental issues related to biomass waste. This approach aligns with the Sustainable Development Goals (SDGs) by offering alternatives to mitigate environmental pollution. The research evaluated hydrolysis and the identification of sugars using Near-Infrared (NIR) technology, which differentiates fermentable sugars like glucose and xylose efficiently, reducing analysis time and costs. NIR technology also aids in selecting promising biomass for industrial use, further enhancing process efficiency and cost-effectiveness. The main conclusions regarding the research must be presented in this topic.

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