Evaluation of *Prosopis juliflora* for Bioethanol Production: Thermogravimetric Analysis and Structural Composition

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***Prosopis juliflora* (*P. juliflora*), known as Algaroba, presents great potential for bioethanol production due to its cellulose- and hemicellulose-rich composition. This study analyzed its biomass through thermogravimetric techniques and structural characterization to assess its energy viability. Samples of woody stem, stem bark, and pods were subjected to thermal and chemical composition analyses, which identified different thermal degradation profiles and structural carbohydrate contents. Results indicated that stem bark presented the highest levels of glucose and cellulose, while lignin showed significant concentration, suggesting the need for pretreatments to optimize bioenergy conversion. Thus, P. juliflora demonstrates potential as a feedstock for biofuels, provided that challenges related to lignin and economic feasibility are overcome.**

Keywords: *Prosopis juliflora*. Biomass. Energy Viability.

Prosopis juliflora (*P. juliflora*), commonly known as Algaroba, is notable for its high adaptability, serving as both a valuable resource and an ecological threat in various ecosystems. Its presence can cause significant environmental impacts, such as alterations to biodiversity and depletion of water resources, making it the subject of numerous studies [1].

In this context, in addition to being an invasive species, *P. juliflora* presents high potential as a feedstock for biofuels due to its lignocellulosic composition, which is rich in cellulose and hemicellulose, characteristics that make it promising for second-generation ethanol production [2].

Its high carbohydrate content enables efficient use in biorefineries, provided that processes such as pretreatment, hydrolysis, and fermentation are optimized. However, challenges such as high lignin concentration, economic feasibility, and environmental impacts of production still need to be addressed. Advancing research to improve conversion techniques and sustainable management is therefore essential to transform this invasive species into a high-value energy resource [2].

This study aimed to evaluate the thermogravimetric profile and the structural carbohydrate and lignin composition of woody stem, stem bark, and pods of *P. juliflora*, in order to assess the bioenergy potential of this biomass.

Materials and Methods

This study was conducted at the Energy and Bioproducts Research Institute of Aston University, Birmingham, England, through an institutional partnership with SENAI CIMATEC University, within the scope of the CAPES Sandwich PhD program. This collaboration provided access to suitable infrastructure for the required analyses.

The methodological stage involved analyzing woody stem, stem bark, and pods from *P. juliflora* biomass using thermogravimetric analysis, structural compound determination, and acid hydrolysis of the untreated sample. Thermogravimetric analysis was performed using

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a Mettler Toledo TGA/DSC 2 STARe system, where 3 mg samples (in triplicate) were heated from 40°C to 900°C at 10°C/min under N_2 flow (30 mL/min), allowing characterization of thermal properties and degradation through mass variation.

Additionally, structural carbohydrate and lignin characterization followed the NREL method [3], where 150 mg of woody stem, bark, and pods were weighed and mixed with H_2SO_4 (72%) and deionized water. After 1 h in a water bath at 30°C and another 1 h in an autoclave at 121°C, the solution was vacuum filtered, neutralized with $CaCO_3$, and analyzed by HPLC to identify glucose, xylose, and arabinose. Thus, the hemicellulose, cellulose, and lignin contents were determined according to the NREL protocol, enabling an assessment of the sustainable biotechnological and industrial potential of *P. juliflora*.

Results and Discussion

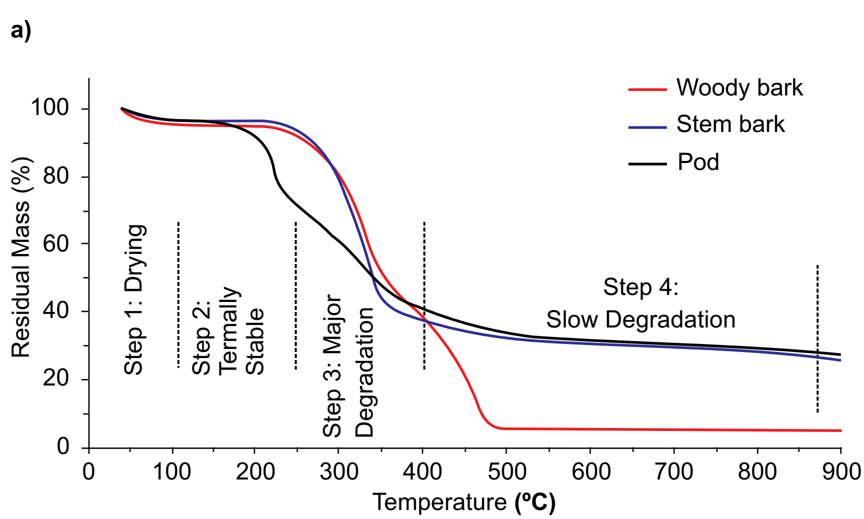
Thermal analyses using the Mettler Toledo TGA/DSC 2 STARe system provided a detailed overview of the thermal degradation of woody stems, bark, and pods of *P. juliflora*. The steps of moisture removal and degradation of hemicellulose, cellulose, and lignin were identified, characterizing thermal behavior and energy potential of the samples.

The results were represented by TGA curves (representing the variation in residual mass with temperature) and DTG curves (the derivative of the TGA curve) (Figure 1).

The DTG curve highlighted the maximum decomposition peaks of each component. The TGA and DTG curves indicated moisture loss between 40°C and 100°C, typical of lignocellulosic biomass, followed by hemicellulose degradation between 202.5°C and 295.3°C, with the pods showing the most pronounced degradation, indicating a higher sugar content. Cellulose degraded between 329°C and 375°C, with greater intensity in woody stem and bark, suggesting a composition favorable to decomposition in this range. Lignin degradation occurred between 425.5°C and 633°C, with a more intense reaction in the woody stem due to its highly cross-linked polymeric structure.

These results confirm previous studies on the thermogravimetric profile of *P. juliflora*, which reported similar degradation ranges for biomass constituents [4-6]. Beyond the thermogravimetric profiles, the lignocellulosic constituents were analyzed, including lignin, glucose, xylose, arabinose, cellulose, and hemicellulose (Figure 2).

Figure 1. TGA (a) and DTG (b) curves of analyzed samples of *P. juliflora* lignocellulosic biomass.



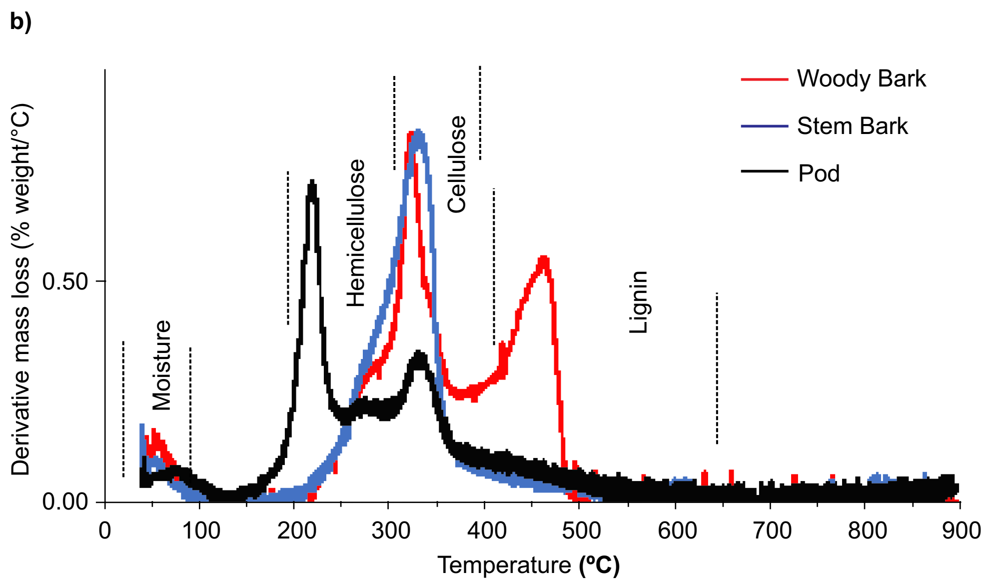
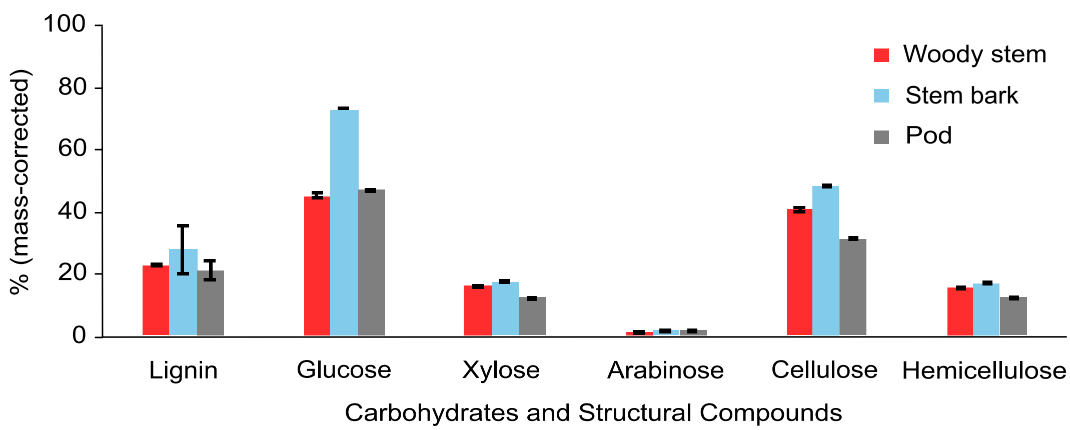


Figure 2. Structural carbohydrate and lignin characterization in woody stem, stem bark, and pods of *P. juliflora*.



The data showed that the stem bark had the highest glucose (73%) and cellulose (48%) contents, indicating strong potential for bioenergy conversion. The woody stem showed intermediate glucose (45%) and cellulose (41%) values, while the pods had slightly lower values (47% and 31%). Hemicellulose was also prominent in stem bark, reinforcing its importance in lignocellulosic biomass, as noted in previous studies [7].

The lignin content was highest in stem bark (28%), followed by woody stem (23%) and pods (19%), indicating a likely need for pretreatments to increase cellulose accessibility in raw biomass. Woody stem values (41% cellulose, 16% hemicellulose, and 23% lignin) align with previous studies, which reported 66% total carbohydrates, whereas this study identified 57%.These results reinforce the viability of *P. juliflora* as a source of biomass for energy production.

Conclusion

The results indicated that *P. juliflora* has strong potential for bioethanol production, particularly from its stem bark, which is rich in cellulose and glucose. Thermogravimetric analysis confirmed its energy viability; however, the high lignin content requires pretreatments to optimize conversion. Thus, *P. juliflora* can be considered a sustainable alternative for biofuels, provided that future studies improve conversion processes and economic feasibility.

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