Fractionation of rice husk for the co-production of biofuel and value-added bioproducts

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Introduction

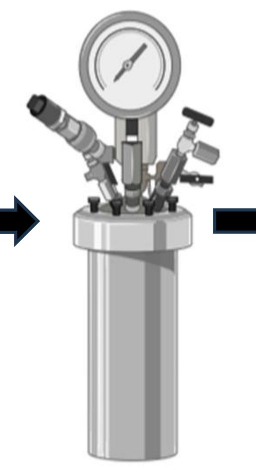
Uruguay, a major rice producer, generates large amounts of rice husk (~1.2 million tons in 2019/2020). Due to its high silica content (~20%) and low biodegradability, this residue is usually underutilized, often burned for energy with limited efficiency. This study explores a biorefinery approach to fractionate rice husk and recover its main components. The aim is to produce bioethanol from glucan-rich solids while valorizing silica, lignin, furfural and succinic acid as value-added co-products.

This strategy supports waste valorization and contributes to the development of a sustainable circular bioeconomy.

Materials and methods

Rice husk
(provided by Galofer SA)

Autohydrolysis



Pretreated solid

Temperature: 180ºC
Time: 30 min
Solid-liquid ratio: 1:5

Alkaline treatment

Silicone oil bath heating circulator (Fibretec Inc.)

2³ factorial design (NaOH load, temperature, reaction time) to **maximize silica** and **lignin solubilization**, and **glucan enzymatic hydrolysis**.

Pretreated solid

Run	Temperature (°C)	NaOH (%)	Time (min)
1	90	16	90
2	90	16	180
3	90	24	90
4	90	24	180
5	150	16	90
6	150	16	180
7	150	24	90
8	150	24	180

Analytical methods:

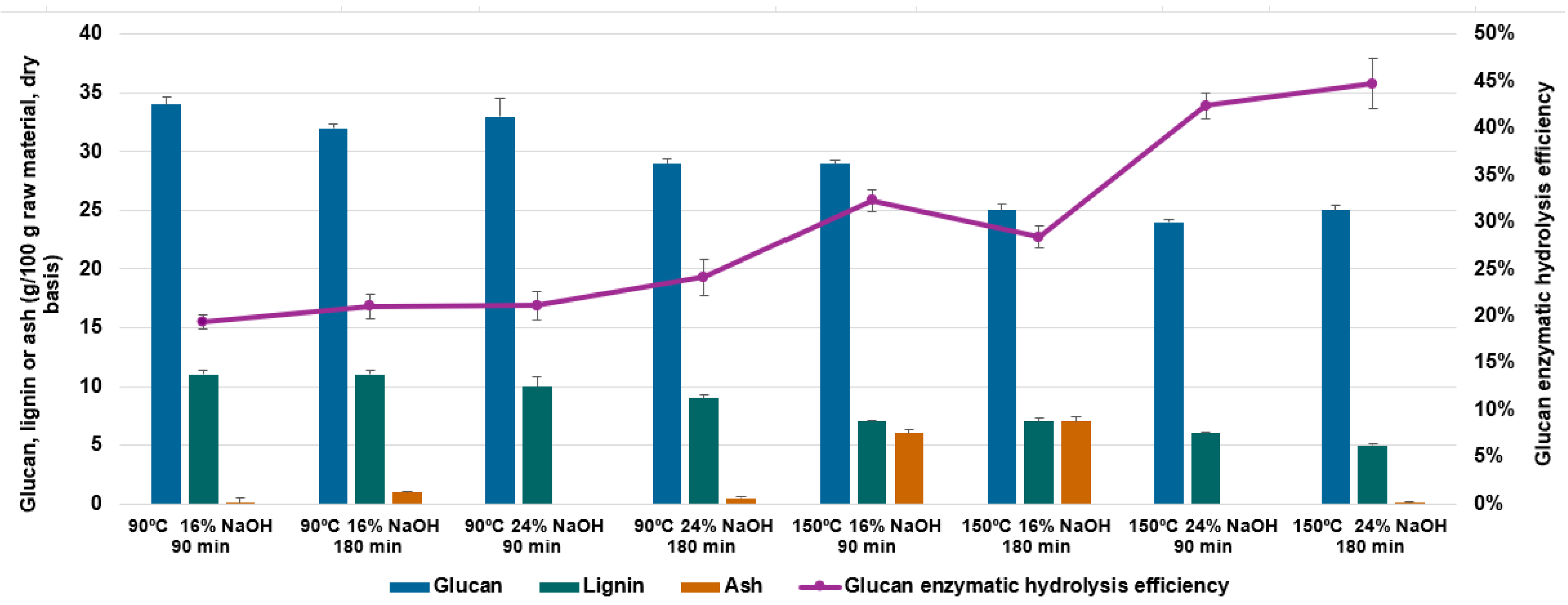
- Chemical composition using NREL protocols[1,2,3,4].
- Enzymatic hydrolysis using Cellic Tec2 following NREL protocol[5].

References

1. A. Sluiter et al. (2008). NREL/TP-510-42619
2. A. Sluiter et al. (2008). NREL/TP-510-42622
3. A. Sluiter et al. (2008). NREL/TP-510-42623.
4. A. Sluiter et al. (2012). NREL/TP-510-42618.
5. M.G. Resch, J.O. Baker, S.R. Decker (2015). Low Solids Enzymatic Saccharification of Lignocellulosic Biomass. NREL/TP-5100-63351.

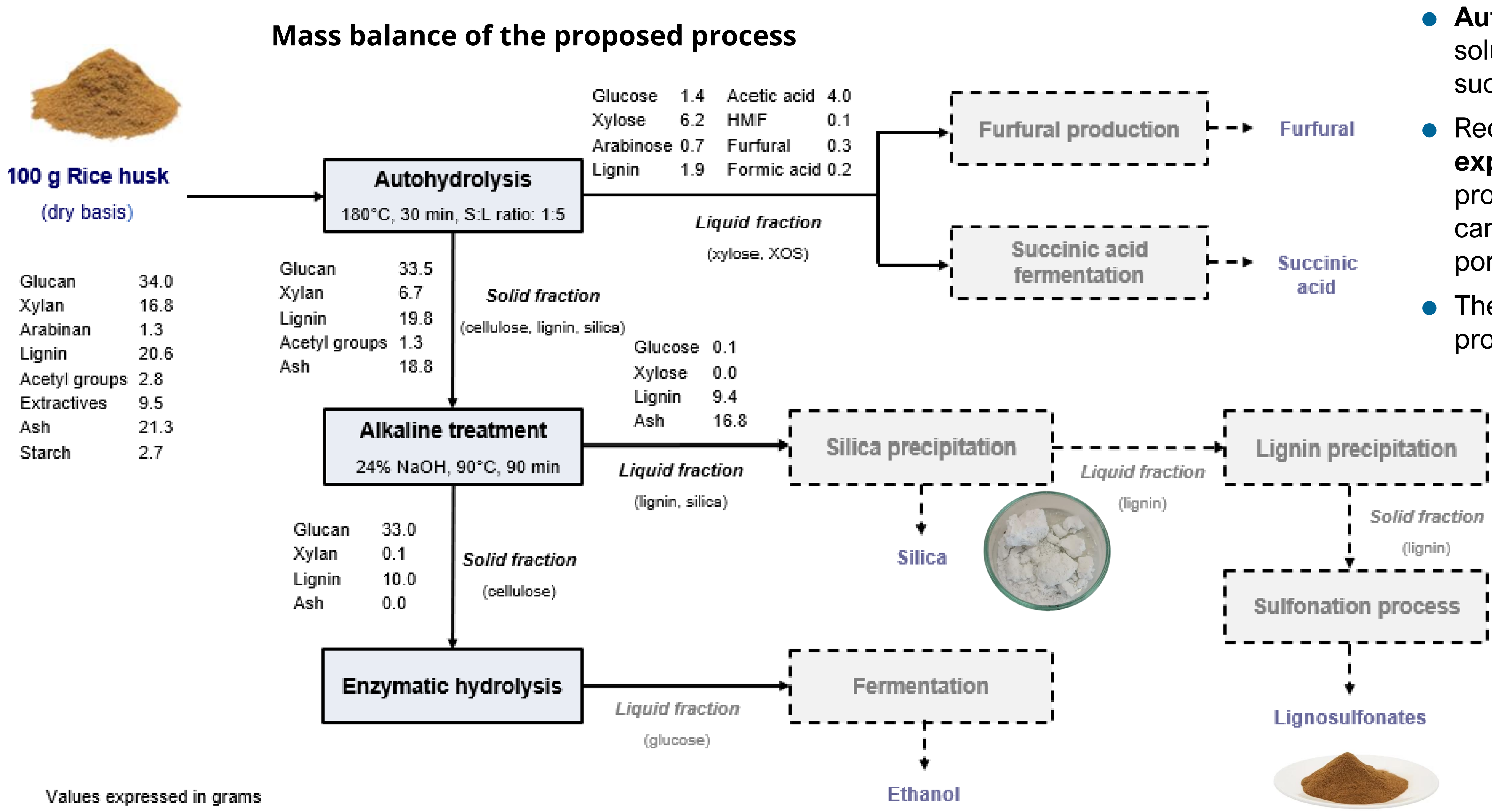
Results and discussion

Solid components (g/100 g raw material)



- **Silica** *vs* **lignin** removal: Optimal conditions for silica extraction (high NaOH load, longer time) differed from those for lignin removal, highlighting the need to optimize parameters according to the target product.
- **Lignin**: Residual lignin in solids ranged from 18–22%, with the lowest values observed at 150°C.
- **Glucan**: The glucan content remained high in all solids (72–87%). Recovery decreased at higher severity, yet solids remained suitable for enzymatic hydrolysis.
- **Enzymatic hydrolysis** increased markedly under alkaline conditions, reaching >40% at 150°C, 24% NaOH, 180 min.
- **At 150°C with 24% NaOH** achieved the best compromise between silica and lignin removal, and glucan recovery with high enzymatic hydrolysis efficiency.

Mass balance of the proposed process



- **Autohydrolysis** enabled selective hemicellulose solubilization, generating a stream for furfural and succinic acid production.
- Recovered **silica** (measured as ash) **will be further explored for applications** such as cement production. This could significantly reduce the overall carbon footprint of cement production by replacing a portion of clinker in cement formulations.
- The **lignin** is separated and will be treated to produce lignosulfonates, a valuable by-product.

The processes studied in this work are depicted with thick lines.

Conclusions

- The integrated strategy (autohydrolysis + alkaline treatment) enabled efficient recovery of silica, lignin, and glucan-rich solids with high enzymatic hydrolysis yields.
- The recovery efficiencies obtained for its main components show that rice husk is a promising waste that can be valorized through a biorefinery.

Acknowledgments

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Rice husk for a circular future