Enhancing Competitiveness in the Rice Value Chain through Biorefinery: A Sustainable and Strategic Approach

C.E. Orrego[1,2], C.A. Cardona[2,3], N. Salgado[2], J.D. Galvis[2]

[1]Departamento de Física y Química, Universidad Nacional de Colombia, Manizales, Caldas, Colombia
[2]Instituto de Biotecnología y Agroindustria, Universidad Nacional de Colombia, Manizales, Caldas, Colombia
3Departamento de Ingeniería Química, Universidad Nacional de Colombia, Manizales, Caldas, Colombia
Keywords: Oryza sativa, Competitive surveillance, normative surveillance, technological surveillance and commercial surveillance
Presenting author email: nsalgadoa@unal.edu.co

Rice (*Oryza sativa*), the third most consumed cereal worldwide, holds significant importance in Colombia. It is grown in 210 municipalities and contributes to up to 80% of the family income in these regions. The rice sector is a substantial source of employment, providing 75,000 direct and 300,000 indirect jobs (MinAgricultura, 2023; Tiempo, 2019).

The current Trade Promotion Agreement between the United States and Colombia provides protection for Colombian rice producers through tariffs. However, these tariffs are expected to be phased out by 2030, which would allow U.S. rice to enter the Colombian market without tariffs. As a result, local rice production could potentially decrease by 40%. To address this challenge, the rice value chain aims to improve its competitiveness by diversifying its products, utilizing agroindustrial waste, and adding value through biorefinery processes. This approach is intended to access new markets and revenue streams, including final products, intermediate goods for various industries, and energy.

Most of the biorefineries described in the literature have only reached the conceptual design stage, which highlights the challenges associated with implementing physical facilities. To enhance applicability and overcome this phase, we propose optimizing the conceptual design process of the biorefinery scheme through strategic surveillance and contextualization of the involved actors. This aims to reduce risks and implementation times of a biorefinery while adhering to sustainability principles and ensuring robust performance from economic, environmental, and social perspectives. (Solarte and Cardona, 2023).

Data on rice crop productivity and by-products resulting from rice milling in the Sucre region of Colombia were collected through bibliographic sources, databases, and primary information. It is estimated that 5 to 10 tons of straw are produced for every hectare of rice harvested (Goodman, 2020). Additionally, when rice is milled into white rice, it produces 20 to 30 kg of husk, 8 to 10 kg of rice bran, and 1 to 2 kg of broken grains per 100 kg of paddy rice (Rodriguez, 2021). These by-products from milling could be utilized as valuable raw materials for developing biorefinery schemes based on existing mills.

After employing strategic surveillance (Castro, 2007) and technological surveillance using 10 search equations across both free and subscription-based databases, we assessed various potential processes and products that could be derived from these raw materials. This resulted in the identification of over 50 products, including cosmetic and food-grade oil (Ijaz et al., 2021; Zhao et.al., 2021), protein hydrolysates (Rodriguez, 2021), bakery flours (Kumari et.al., 2019), functional ingredients, texture enhancers (Parvez and Gautam, 2014), and bioactive compounds like orynazol (Li, et. al., 2021). These products can serve as final or platform products for industries such as pharmaceutical, food, cosmetic, and energy. The gathered information was refined by correlating it with sustainability studies and conducting regulatory surveillance within the country for future production and commercialization. We also conducted competitive surveillance (to understand existing products, processes, and substitute products in the market) and commercial surveillance to identify potential clients and suppliers within the rice value chain. Lastly, we surveyed the installed capacity of rice mills, focusing on small and medium-scale millers as they represent the most significant group likely to implement the biorefinery. It was crucial to evaluate their technological capabilities to assess potential processes for implementation.

These surveillance efforts led to the identification of a limited number of biorefinery schemes with a high likelihood of implementation, which can be summarized in Figure 1.

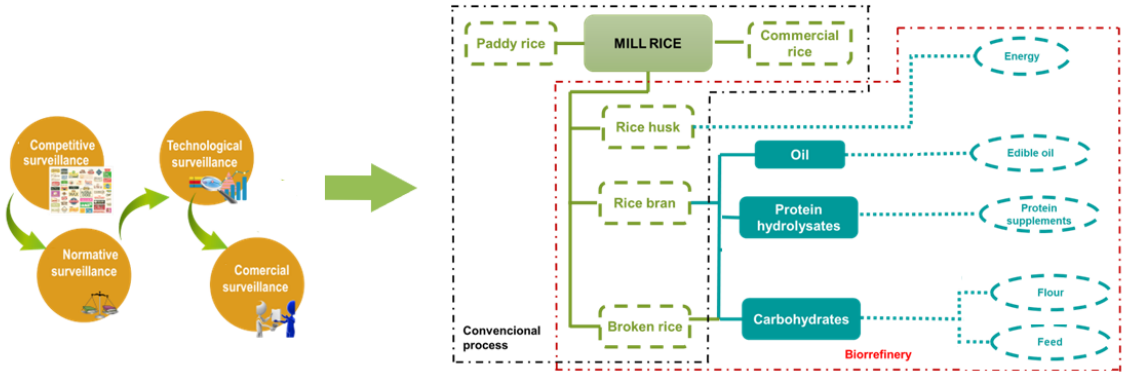

Figure 1. Potential biorefinery pathways for the valorization of by-products from rice mill. The black dashed lines represent the typical current process of rice milling. The red dashed lines depict the general arrangement of the biorefinery, while the blue dashed lines provide examples of the uses or applications of the output products.

Conclusions

To advance the conceptual design stage, enhance applicability, and reduce implementation challenges, we propose suitable biorefinery pathways for current small to medium-sized rice mills. These pathways are based on the results of technological, regulatory, and competitive surveillance, supplemented with sustainability studies, regulatory surveillance, and the contextualization of the involved stakeholders.

Future efforts will concentrate on quantifying mass and energy fluxes and outlining the integration of the proposed processes within the biorefinery concept. This will be supplemented with an all-encompassing roadmap that takes into account sustainability indices spanning technical, environmental, economic, and social aspects, the technological maturity index of the processes involved, and the resource search strategy needed for their execution.

Acknowledgement

The authors express their gratitude to the research program entitled “BPIN 2020000100189. “Aprovechamiento y valorización sostenible de residuos sólidos orgánicos y su posible aplicación en biorrefinerías y tecnologías de Residuos a Energía en el Departamento de Sucre” and Margaret McNamara Education Grants

References

Castro, S. (2007). Guía práctica de vigilancia estratégica. España: CEMITEC, Agencia Navarra de Innovación.

Goodman, B. A. (2020). Utilization of waste straw and husks from rice production: A review. Journal of Bioresources and Bioproducts, 5(3), 143–162.

Ijaz, U., Nadeem, H. U., Shafique, A., Rasheed, A., Batool, R., & Azeem, F. (2021). Rice bran composition and its emerging potential applications. In Green Sustainable Process for Chemical and Environmental Engineering and Science (pp. 1-16). Elsevier.

Kumari, N., & Khetarpaul, N. (2019). Value added egg muffins incorporating full fat rice bran (10 and 20%) and flax seeds (10%). Journal of Pharmacognosy and Phytochemistry, 8(5), 2374-2377.

Li, D., Zhang, J., Faiza, M., Shi, L., Wang, W., Liu, N., & Wang, Y. (2021). The enhancement of rice bran oil quality through a novel moderate biorefining process. LWT, 151, 112118.

MinAgricultura. (2023). Agronet. https://www.agronet.gov.co/estadistica/Paginas/ home.aspx?cod=1. Consultado el 5 de marzo de 2023

Rodriguez, Y. (2021). Production of protein hydrolysate from rice brain using immobilized protease of lignocellulosic waste. Universidad Nacional de Colombia Sede Manizales

Solarte-Toro, J. C., Laghezza, M., Fiore, S., Berruti, F., Moustakas, K., & Alzate, C. A. C. (2022). Review of the impact of socio-economic conditions on the development and implementation of biorefineries. Fuel, 328, 125169

Tiempo, E. (2019). Los principales proyectos del Ministerio de Agricultura. In Economía. https://www.eltiempo.com/economia/los-principales-proyectos-del-ministerio-de-agricultura-441546

Zhao, X., Wu, Y., Shi, Y., Liang, Y., Feng, X., Sun, Y., ... & Zhao, G. (2021). Non-adiabatic dynamics mechanism in excited state of novel UV protective sunscreen in rice: Conical intersection promotes internal conversion. Journal of Cluster Science, 32, 967-97