

# Turning Agri-Food By-Products into Functional Ingredients: Sustainable Innovations for Waste Reduction

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## Introduction

**Environmental Impact:** The beverage industry generates large amounts of food by-products, contributing to waste and sustainability challenges.

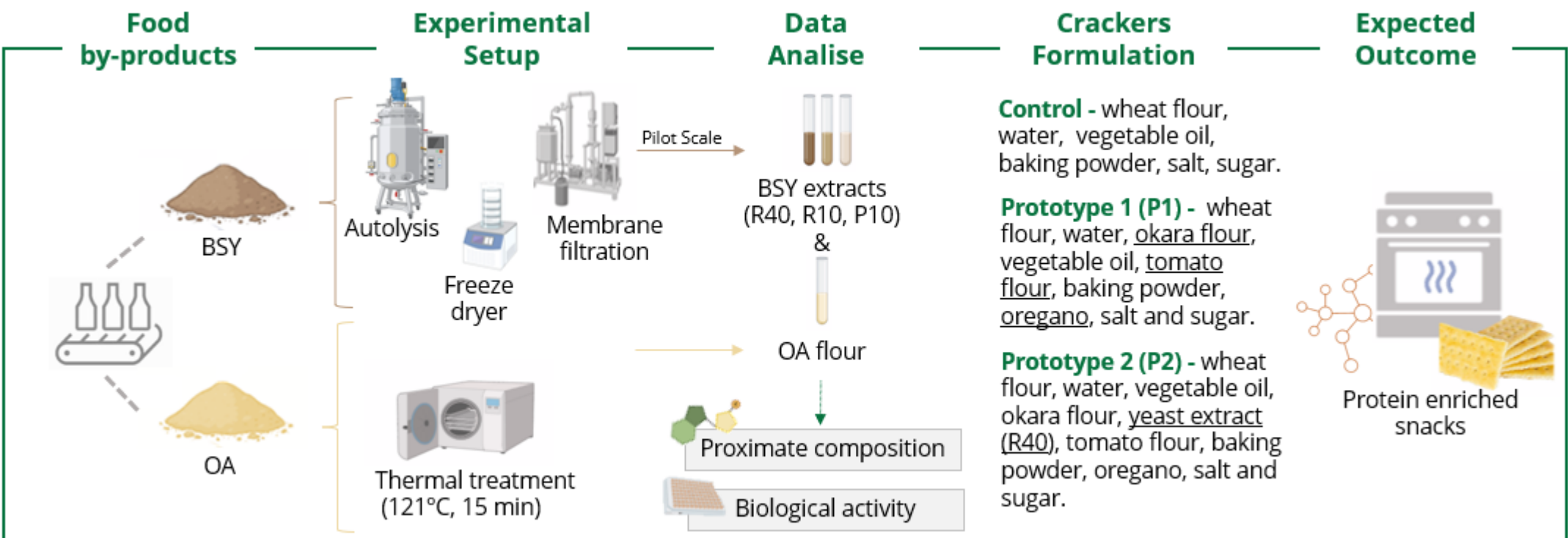
**Nutritional & Economic Value:** Brewer’s spent yeast (BSY) and rice Okara (OA) are by-products rich in proteins, fibers and bioactive compounds, offering both health benefits and cost-effective opportunities.

**Contribution to a Sustainable Food System:** The utilization of these by-products enhances resource efficiency and promotes the principles of a circular economy.

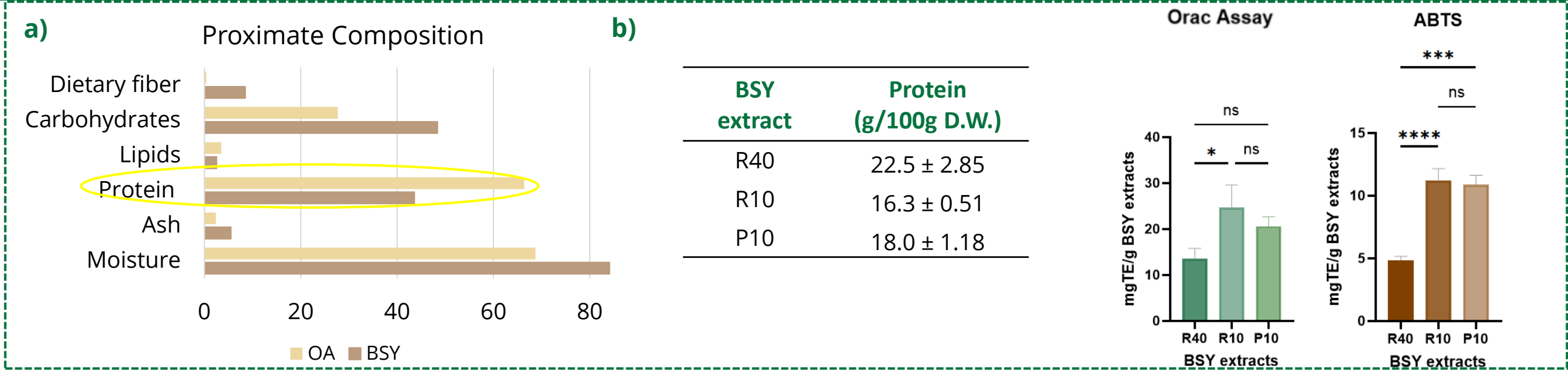
## Objective

This study aims to enhance the valorisation of BSY and OA by-products, converting them into high-quality ingredients for formulating protein-enriched snacks through a green and environmentally sustainable process.

## Methodology



## Results & Conclusion



**Figure1. a)** Proximate Composition of by-products **b)** Protein Quantification and Antioxidant Capacity (ORAC and ABTS assays) of different BSY extracts (R40 corresponds to the retentate of 40 kDa membrane, R10 to the retentate of 10 kDa membrane, and P10 to the permeate of 10 kDa membrane). Data are presented as mean ± SD from three replicates. \* Indicates a statistically significant difference at  $p < 0.05$ , while ns indicates non-significant differences.

- ✓ **Protein Potential-** BSY and OA by-products serve as valuable sources for protein enrichment.
- ✓ **Extract Selection-** R40 stands out as the fraction with the highest protein content and still exhibits significant bioactivity, even though R10 and P10 show significantly higher values. R40 extract was chosen for the crackers’ formulation.

**Table 1.** Physicochemical and Textural Properties of Crackers. Data are presented as mean ± SD from three replicates. Different letters indicate significant differences at  $p < 0.05$ .

| Parameters                       | Control                  | P1                       | P 2                      |
|----------------------------------|--------------------------|--------------------------|--------------------------|
| Moisture (%)                     | 12.8 ± 1.65 <sup>a</sup> | 18.4 ± 1.34 <sup>a</sup> | 18.7 ± 0.93 <sup>b</sup> |
| Protein (g/100gDW)               | 10.4 ± 0.61 <sup>b</sup> | 20.6 ± 0.50 <sup>a</sup> | 20.9 ± 0.56 <sup>a</sup> |
| Water Activity (a <sub>w</sub> ) | 0.86 ± 0.00 <sup>a</sup> | 0.84 ± 0.00 <sup>b</sup> | 0.65 ± 0.01 <sup>c</sup> |
| L*                               | 68.9 ± 1.56 <sup>a</sup> | 49.9 ± 1.58 <sup>b</sup> | 51.8 ± 1.69 <sup>b</sup> |
| a*                               | 2.35 ± 0.03 <sup>a</sup> | 7.27 ± 0.11 <sup>b</sup> | 6.73 ± 0.20 <sup>c</sup> |
| b*                               | 16.5 ± 0.25 <sup>a</sup> | 26.3 ± 0.22 <sup>b</sup> | 24.2 ± 0.75 <sup>a</sup> |
| Hardness (N)                     | 86.8 ± 27.1 <sup>a</sup> | 99.3 ± 12.4 <sup>a</sup> | 79.0 ± 16.1 <sup>a</sup> |
| Fracturability (mm)              | 19.5 ± 1.11 <sup>a</sup> | 14.6 ± 1.58 <sup>b</sup> | 10.8 ± 0.36 <sup>c</sup> |

### Crackers Properties

- 💧 **Moisture content**  
P1 and P2 exhibited higher moisture content compared to the control. This increase may influence shelf stability and texture.
- 👤 **Protein Enrichment**  
P1 and P2 showed significantly higher protein content than the control, demonstrating nutritional enhancement.
- 💧 **Water Activity**  
Prototypes showed lower water activity (P2 < P1 < Control), suggesting improved microbial stability.
- 🎨 **Color Analysis**  
Both prototypes (P1 and P2) were significantly darker (lower L\*), redder (higher a\*), and yellower (higher b\*) than the control, likely due to Maillard reactions or ingredient differences. These differences may affect consumer perception.
- 🔪 **Texture**  
P1 was harder than the control, while P2 was softer, indicating distinct textural profiles between the prototypes. P1 and P2 were less fracturable than the control.

✳️ **FINAL CONCLUSION:** Incorporating BSY extracts and OA into cracker formulations significantly enhances protein content and textural properties. This study promotes resource efficiency, contributes to sustainability goals, and aligns with the principles of the circular economy in food production.

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