TOWARDS HYBRID YOGHURTS: INFLUENCE OF PLANT PROTEIN TYPE ON PHYSICAL AND FUNCTIONAL CHARACTERISTICS

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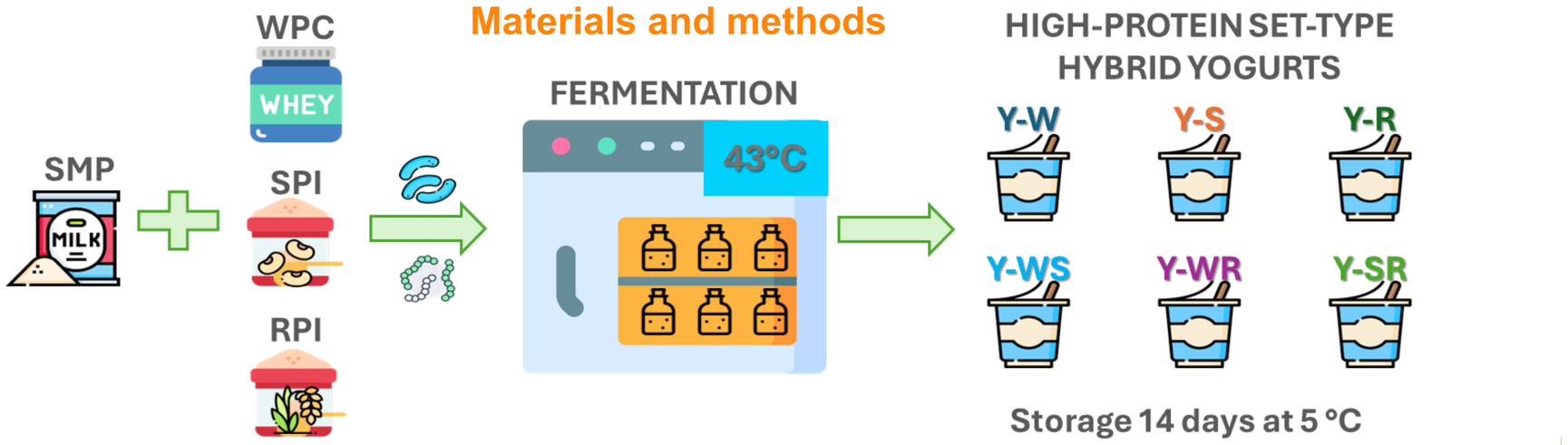
Abstract

'This study explored the physical and functional properties of set-type hybrid yogurts where milk protein (3%) was partially replaced by plant-based proteins (3%): soy protein isolate (SPI), rice protein isolate (RPI), or their blends, maintaining a 6% total protein content. This substitution aims to lower the carbon footprint of dairy products. Six yogurt formulations were fermented with standard cultures until pH 4.5. Key findings were: Fermentation Time: Soy protein (SPI) accelerated fermentation (3.5h), while rice protein (RPI) delayed it (5h) compared to the control (4.5h); Texture and Stability: SPI-containing yogurts showed texture parameters (firmness, consistency) closest to the control. RPI-containing yogurts resulted in a weaker gel and significantly higher syneresis (up to 64% forced). Rheology and Microstructure: All yogurts displayed viscoelastic solid-like behavior. However, RPI led to the weakest structure (lowest G'). Microstructure analysis suggested that plant proteins formed self-aggregates instead of fully integrating with milk proteins, resulting in less dense gels than the control. In conclusion, soy protein is the most suitable alternative for maintaining the functional properties of hybrid yogurts, while rice protein significantly compromises texture and stability.

Introduction

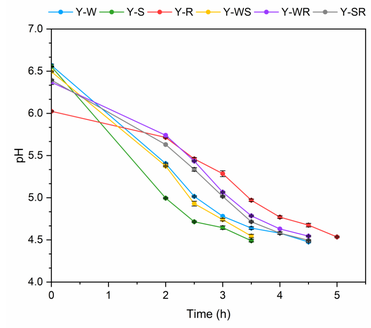
Hybrid foods, which blend plant-based ingredients into traditional animal products, are emerging as a sustainable strategy to meet global food demand and reduce the environmental footprint. This new category aims to combine the nutritional benefits of both sources while enhancing dietary diversity. Despite their potential, research on hybrid yogurts is limited. Formulation is key, particularly the selection and concentration of the plant protein. Fermentation is critical for developing the proper texture and improving gelation, especially for high-protein set-type yogurts, which are popular for their health benefits (e.g., weight management). This study investigates the effect of two popular plant proteins—soy protein isolate (SPI) and rice protein isolate (RPI)—on the microbiological, physicochemical, and structural properties of high-protein set-type hybrid yogurts.

Materials and methods

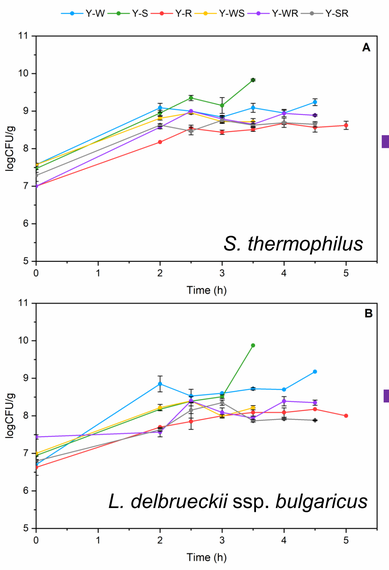


Results

Fermentation behavior



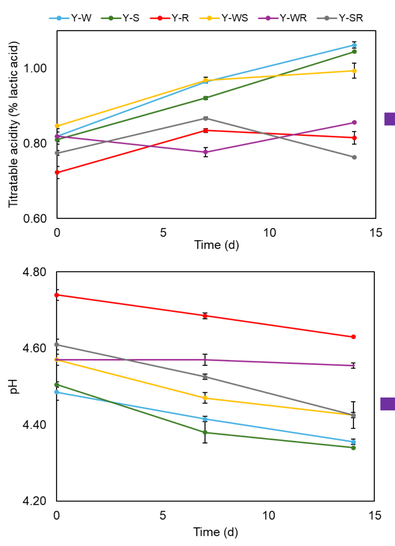
Yogurts containing soy protein (Y-S) and whey and soy protein (Y-WS) reached the shortest endpoint in 3.5 h. Yogurt with rice protein (Y-R) had the longest fermentation time (5 h), while Y-W, Y-WR and Y-SR had an intermediate fermentation time (4.5 h).



Y-S showed the highest bacterial counts (9.8 log CFU/g) at the end of the fermentation process. The hybrid yogurts containing rice protein (Y-R, Y-WS and Y-SR) showed the lowest bacterial counts (~8.6-8.7 log CFU/g) by the end of fermentation.

Y-S had the highest log count in 3.5 h (9.83 log CFU/g), followed by Y-W (9.24 log CFU/g). *L. delbrueckii ssp. bulgaricus* reached 7.88 - 8.35 log CFU/g in the remaining samples.

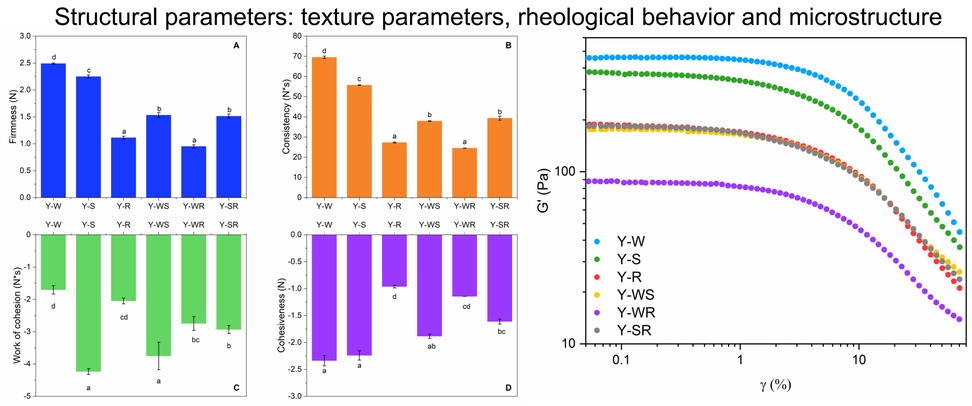
Titratable acidity and pH

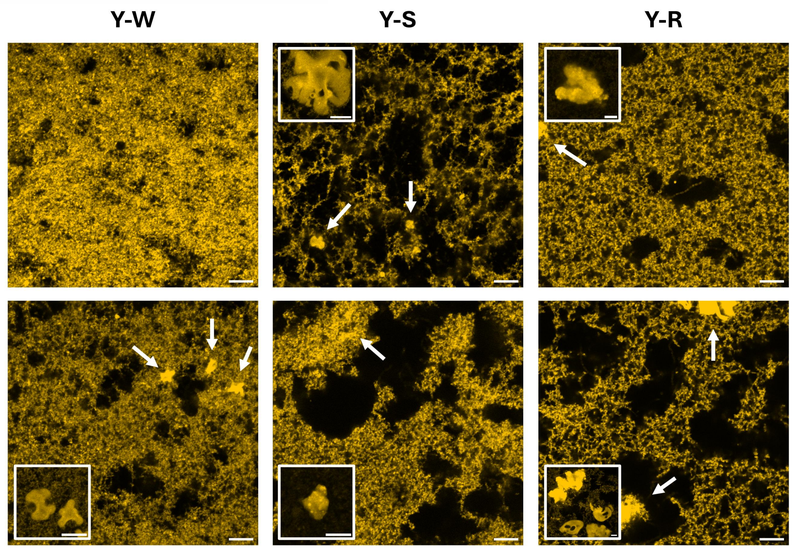


Y-W and Y-S showed the highest increase in acidity. Y-R, Y-WR and Y-SR had the lowest acidity values.

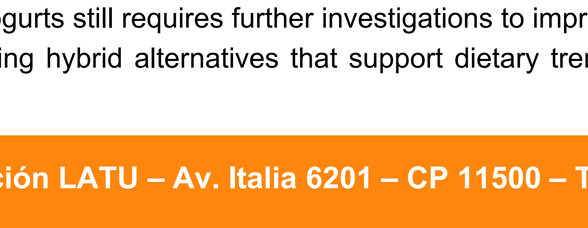
The pH declined significantly in all samples, except Y-WR. The pH in Y-W and Y-S (4.36 and 4.34, respectively) was significantly lower than in the remaining samples

Structural parameters: texture parameters, rheological behavior and microstructure





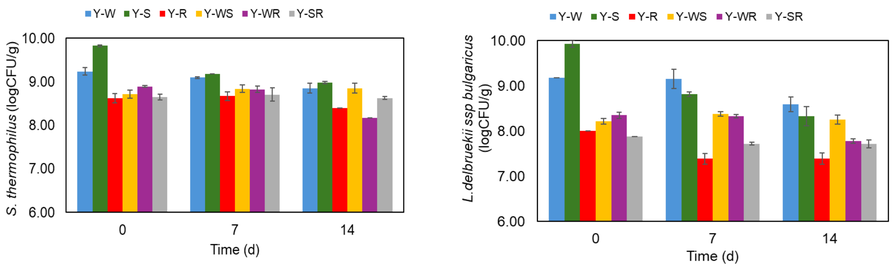
Spontaneous (A) and centrifuged (B) syneresis at day 0 (solid), 7 (diagonal lines) and 14 (horizontal lines) of storage at 5 °C.



Y-R sample showed the highest level of spontaneous syneresis. Y-R and Y-SR presented the highest centrifuged syneresis. The yogurts containing WPC (Y-W, Y-WS and Y-WR) presented the lowest centrifuged syneresis on day 14.

Microbial count during storage at 5°C

LAB count was above 7 log CFU/g in all samples, the minimum concentration required to be considered a functional food



Color parameters and total solids

Sample	Total solids (%, w/w)	L*	a*	b*	WI
Y-W	21.56 ± 0.07 ^{a}	91.7 ± 0.0 ^{d}	-1.5 ± 0.2 ^{a}	13.6 ± 0.1 ^{a}	84.0 ± 0.1 ^{e}
Y-S	21.38 ± 0.13 ^{a}	85.0 ± 0.3 ^{b}	0.9 ± 0.1 ^{e}	17.0 ± 0.0 ^{c}	77.3 ± 0.2 ^{b}
Y-R	21.43 ± 0.23 ^{a}	83.8 ± 0.3 ^{a}	0.3 ± 0.1 ^{cd}	17.7 ± 0.0 ^{d}	76.0 ± 0.2 ^{a}
Y-WS	21.59 ± 0.08 ^{a}	87.4 ± 0.4 ^{c}	-0.5 ± 0.2 ^{b}	14.5 ± 0.0 ^{b}	80.8 ± 0.2 ^{c}
Y-WR	22.33 ± 0.02 ^{b}	86.8 ± 0.1 ^{c}	0.1 ± 0.0 ^{cd}	17.1 ± 0.3 ^{c}	78.4 ± 0.3 ^{d}
Y-SR	21.72 ± 0.14 ^{a}	84.5 ± 0.0 ^{ab}	0.8 ± 0.1 ^{de}	18.0 ± 0.0 ^{d}	76.3 ± 0.0 ^{a}

WI: whiteness index. Different lowercase letters in the same column mean significant differences between samples ($P \leq 0.05$).

Y-W presented the highest luminosity (L*), while Y-R was the least luminous yogurt. Regarding a* and b*, Y-W and Y-WS presented the lowest values. The dairy yogurt had a white-creamy color, while hybrid yogurt had a slight brownish hue, especially Y-R.

- Y-W showed the highest firmness, consistency and cohesiveness and the lowest work of cohesion. The yogurts produced by addition of soy protein alone (Y-S), presented the most similar texture profile to Y-W, while Y-R yielding the lowest values for all texture parameters.
- All samples exhibited viscoelastic solid-like behavior.
- Y-W exhibited a dense and compact gel network. The hybrid yogurts exhibited different microstructure features, highlighting the influence of protein composition on gel formation. Y-S resulted in the formation of a branched protein network, that was markedly less dense and more porous. Y-WS produced an intermediate microstructure between Y-W and Y-S. Y-R displayed a loose and branched structure, with large pores distributed throughout the gel. Y-WR did not yield an intermediate structure, but rather accentuated porosity, with larger pores. Y-SR showed a structure resembling Y-S but more compact, with large pores similar to those on Y-R and Y-WR. All hybrid yogurts contained bright yellow particles consistent with plant protein aggregates.

Conclusions

- The type of plant protein significantly affected yogurt quality in terms of fermentation time, microbial viability, syneresis, and structural properties. These factors are crucial for consumer acceptance and for the practical application of plant proteins in hybrid yogurt formulations. Soy protein showed the most promising results, as it reduced manufacturing time, and could potentially lower production costs. By contrast, the inclusion of rice proteins negatively impacted the textural properties and water-holding capacity of the yogurts.
- The use of rice proteins in the development of hybrid yogurts still requires further investigations to improve their functional properties, particularly their solubility.
- The findings of this study provide insights into producing hybrid alternatives that support dietary trends towards reducing animal protein consumption, while maintaining the sensory quality of traditional dairy products.