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From Waste to Resource: Pomegranate By-products Valorisation with Native Hanseniaspora Valbyensis for Functional Food Design

John P. Morrissey[1], Maria Calasso[2], Maria De Angelis[2] and Fabio Minervini[2]

[1]*University College Cork, Ireland*
[2]*Università degli Studi di Bari, Italy*

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Abstract

Pomegranate microbiota is primarily composed of yeasts, typically colonizing the fruit's surface. This study identified four distinct strains of Hanseniaspora valbyensis from both pomegranate juice (PJ) and seeds (PS), suggesting a targeted migration and adaptation from the fruit's outer layer. Among non-conventional yeasts, H. valbyensis is particularly notable for its significant production of aroma compounds during fermentation. Despite the known sensitivity of this genus to ethanol or antimicrobials, these specific strains demonstrated the ability to produce ethanol levels comparable to the control, Saccharomyces cerevisiae, under specific conditions. Upon sugar depletion, H. valbyensis secreted acetate, which remained unmetabolized in the absence of oxygen. Although glucose and fructose seemed to be simultaneously consumed, no specific fructose transporter was identified through genomic screening. To address this, phylogenetic reconstruction was performed, highlighting the evolutionary complexity of Ffz-like genes. This analysis suggested that multiple uncharacterized fructose transporter lineages may have emerged from the DHA1 family, providing new insights into the evolutionary adaptation of this yeast's sugar metabolism. Besides that, H. valbyensis thrived in challenging matrices characterized by low pH and presence of antimicrobials. Leveraging these unique metabolic traits, this study explores the biotechnological potential of this species to valorize pomegranate seeds, a nutrient-dense byproduct of the juice industry rich in proteins, fiber, and ellagitannins. Historically discarded as waste, these seeds are here treated as a high-value co-product for fermentation. Preliminary fermentation tests showed that all H. valbyensis strains could alter the seeds' chemical composition, specifically regarding mineral and organic acid profiles. The most promising results were observed using strains S-L1 and J-L6. To validate the application, a functional granola snack was developed by incorporating pomegranate seed flour (PSF) fermented with strain S-L1. Three formulations were evaluated: granola with fermented PSF (G-FS), with unprocessed PSF (G-US), and conventional granola (G-C). Results revealed that PSF inclusion significantly improved antioxidant capacity, with G-FS reaching 60% DPPH• scavenging activity. Furthermore, the fortified snacks exhibited higher mineral content and lower energy values than the control. Sensory evaluation confirmed that fermentation improved palatability, with G-FS scoring 6.3 (1–9 scale) compared to 4.9 for G-US, demonstrating the potential of H. valbyensis for upcycling industrial byproducts into nutritious, consumer-accepted food ingredients.

Keywords: by-product, pomegranate seeds, non-Saccharomyces yeast, granola snack