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Sustainable proteins, unexpected nutrition: How fractionation and extrusion shape digestibility and texture of meat analogues?

Ding Xiang Chew[a*], Alicia Theng[a], Sze Ying Leong[b], Caleb Ong[a], Zhi Ying Ho, Jason Wong[a], Raffael Osen[a], Jie Hong Chiang[a†]

[a] *Singapore Institute of Food and Biotechnology Innovation (SIFBI), Agency for Science, Technology and Research (A*STAR), 31 Biopolis Way, Nanos, Singapore 138669*
[b] *School of Biosciences, Faculty of Health and Medical Sciences, Taylor's University, 47500 Subang Jaya, Selangor, Malaysia*

Abstract

Dry protein fractionation has emerged as a sustainable alternative to conventional wet extraction due to its substantially lower water and energy requirements [1]. However, the nutritional implications of incorporating dry-fractionated protein concentrates (DFPC) into structured foods such as plant-based meat analogues remain poorly understood. It is unclear whether digestibility differences observed at the ingredient level persist following extrusion-induced structural transformations. This study investigated the effects of the fractionation route on protein quality and consumer perception in high-moisture meat analogues produced from faba bean (FB) and pea (P) proteins. Extrudates were formulated by partially replacing wet-extracted protein isolates (WEPI) with DFPC at increasing levels (up to 25%). Protein quality was evaluated using digestible indispensable amino acid content and *in vitro* digestible indispensable amino acid scores (IVDIAAS), while sensory texture perception was assessed by 75 consumers. At the ingredient level, fractionation effects were protein-source dependent. FP-WEPI exhibited substantially higher digestibility than FB-DFPC, whereas the opposite trend was observed for P proteins. After extrusion, however, the nutritional outcomes did not simply reflect ingredient digestibility. Incorporation of FB-DFPC unexpectedly improved the IVDIAAS of extrudates, especially at 25% substitution, suggesting that extrusion-induced structural transformations enhanced enzyme accessibility. In contrast, although the P-DFPC ingredient is more digestible, its substitution did not further improve the digestibility of P extrudates, suggesting that heat-induced protein aggregation during extrusion may limit enzymatic susceptibility. Consumer sensory evaluation further revealed that protein source dominated texture perception. FB extrudates were perceived as harder and drier, whereas pea extrudates exhibited lower hardness and received higher consumer preference scores. These findings highlight a critical sustainability–nutrition trade-off in alternative proteins: while dry fractionation offers environmental advantages, its nutritional performance depends strongly on protein source and processing conditions during structuring. The results demonstrate that the interplay between ingredient functionality and extrusion-induced structural changes must be considered when developing sustainable plant-based meat products.

References

[1] Dumoulin, L., Jacquet, N., Malumba, P., Richel, A., & Blecker, C. (2021). Dry and wet fractionation of plant proteins: How a hybrid process increases yield and impacts nutritional value of faba beans proteins. *Innovative Food Science & Emerging Technologies*, *72*, 102747.

* Corresponding author *E-mail address:* chew_ding_xiang@a-star.edu.sg
* Corresponding author *E-mail address:* chiang_jie_hong@a-star.edu.sg