

Ultrasound-Enhanced Gelation and Functional Properties of Faba Bean Protein for Clean-Label Food Applications

Abstract

Faba bean (*Vicia faba* L.) protein has gained significant attention as a sustainable, allergen-friendly alternative in plant-based food formulations. However, its native gelling and techno-functional properties often require improvement to meet product development needs. This study investigates the effect of ultrasound treatment on the gelation behavior and functional attributes of faba bean protein isolate to enhance its performance in clean-label food systems. Given the increasing consumer demand for natural and minimally processed ingredients, ultrasound offers a non-thermal, environmentally friendly approach to protein modification that preserves nutritional quality.

Moderate-frequency ultrasound (40 kHz) was applied under controlled conditions to modify protein structure and interactions. Treated samples demonstrated improved solubility, reduced particle size, and enhanced surface activity. These modifications translated into significantly increased water-holding capacity, emulsifying ability, and gel strength. Rheological analysis revealed stronger, more elastic gel networks, while FTIR spectroscopy confirmed ultrasound-induced conformational changes, such as increased β -sheet content and partial unfolding—favorable for gel matrix formation.

The results suggest that ultrasound is a promising green processing method to enhance the functionality of faba bean protein without the need for chemical additives. This technique enables the development of structured, high-protein plant-based foods, including meat analogs, dairy alternatives, and nutritionally enriched gels. The study contributes to sustainable innovation in functional food design, aligning with consumer demand for minimally processed, protein-rich products.

Keywords: Faba bean protein; ultrasound treatment; gelation behavior; functional food formulation; techno-functional properties