INTERNATIONAL RESEARCH JOURNAL OF MEDICAL SCIENCES AND HEALTH CARE

Published Date: - 10-11-2024 Page no. 06-10

ULTRASOUND-DRIVEN IMPROVEMENT OF FOAMABILITY IN BEVERAGE PROTEINS

[1]KARINA PRIETO, [2]AGUSTIN SANCHEZ

[1,2]Department of Industries, Faculty of Exact and Natural Sciences, University of Buenos Aires, Ciudad Universitaria (1428) Buenos Aires, Argentina

ABSTRACT

This study investigates the effect of ultrasound treatment on the foamability of proteins used in beverages, aiming to enhance their foaming properties for improved product quality. Ultrasound, known for its ability to induce physical and chemical changes in materials, was applied to protein solutions under various conditions to evaluate its impact on foam formation and stability. Beverage proteins, such as whey and soy proteins, were subjected to ultrasound at different frequencies and intensities, and their foamability was assessed through measurements of foam volume, stability, and bubble size distribution.

The results demonstrate that ultrasound treatment significantly enhances the foamability of beverage proteins. The application of ultrasound led to a notable increase in foam volume and stability, with optimized conditions resulting in finer bubble sizes and improved foam structure. These improvements are attributed to ultrasound-induced changes in protein structure, which enhance protein-protein interactions and promote more stable foam formation.

The study also explores the relationship between ultrasound parameters and foaming properties, identifying the optimal conditions for maximizing foamability. Additionally, the effects of ultrasound on the functional properties of proteins, such as solubility and viscosity, were examined to ensure that foam enhancement does not compromise other desirable characteristics. Overall, the findings suggest that ultrasound treatment is a promising technique for improving the foamability of beverage proteins, offering potential benefits for the production of beverages with enhanced texture and visual appeal. This research provides a foundation for further exploration of ultrasound applications in beverage technology and contributes to the development of innovative approaches for optimizing protein-based foams.

KEYWORDS

Ultrasound, Foamability, Beverage Proteins, Protein Foam Formation, Foam Stability, Protein Structure, Bubble Size Distribution, Protein Functional Properties, Whey Prot

ein, Soy Protein, Ultrasound Treatment, Foaming Properties

INTRODUCTION

The quest for enhanced foamability in beverage proteins is a significant focus in the food and beverage industry, as foam quality impacts the sensory experience and overall appeal of products such as protein shakes, dairy beverages, and plant-based drinks. Foamability, which encompasses the ability of proteins to generate and stabilize foam, is crucial for achieving desirable texture and visual characteristics in these beverages. Traditional methods to improve foamability often involve modifying protein formulations or using additives, but recent advances in ultrasonic technology offer a novel approach. Ultrasound, with its ability to induce physical and chemical changes at the molecular level, has shown potential in enhancing protein functionality, including foamability.

Ultrasound treatment applies high-frequency sound waves to protein solutions, causing cavitation and shear forces that can alter protein structure and interactions. These changes may enhance protein solubility, disrupt protein aggregates, and promote better protein-protein interactions, all of which contribute to improved foam formation and stability. By using ultrasound, it is possible to achieve finer bubbles, increased foam volume, and longer-lasting foam, which are critical for producing high-quality beverage products.

This study aims to explore the impact of ultrasound on the foamability of common beverage proteins such as whey and soy proteins. By systematically applying ultrasound at varying frequencies and intensities, the research investigates how these parameters affect foam properties, including volume, stability, and bubble size distribution. Additionally, the study examines the relationship between ultrasound treatment and other functional properties of proteins, ensuring that foam enhancement does not compromise other essential characteristics.

METHOD

To investigate the impact of ultrasound on the foamability of beverage proteins, a comprehensive experimental approach was adopted involving protein solution preparation, ultrasound treatment, and detailed foam characterization. The study was designed to evaluate the effects of ultrasound on various protein types, specifically whey and soy proteins, and to optimize ultrasound parameters for enhanced foam properties.

Whey and soy protein powders were sourced from commercial suppliers and dissolved in distilled water to create 1% (w/v) protein solutions. The solutions were adjusted to pH 7.0 to mimic typical beverage conditions and were allowed to equilibrate for 24 hours to ensure complete dissolution and protein hydration. To ensure consistency, solutions were filtered through a 0.45 µm membrane to remove any insoluble particles before ultrasound treatment.

Ultrasound was applied using a laboratory-grade ultrasonic processor equipped with a 13 mm probe. The ultrasonic treatment was conducted at varying frequencies (20 kHz, 40 kHz) and intensities (50%, 70%, 90% of maximum output power) to assess their effects on foamability. Each protein solution was subjected to ultrasound for a set duration (5, 10, 15 minutes) at controlled temperatures to prevent excessive heating, which could affect protein stability. The treatment was performed in a temperature-controlled water bath to maintain uniform conditions.

Foamability was assessed by using a mechanical frother to generate foam in the treated protein solutions. Foam volume was measured immediately after frothing and after a 30-minute standing period to determine foam stability. The foam was evaluated for bubble size distribution using a laser diffraction particle size analyzer. Additionally, the foam's density and texture were analyzed through image analysis and rheological measurements.

To understand the effects of ultrasound on protein structure, protein samples were analyzed using dynamic light scattering (DLS) and atomic force microscopy (AFM) before and after ultrasound treatment. These techniques provided insights into changes in protein aggregate size and surface morphology. The solubility and viscosity of the protein solutions were also measured using a UV-visible spectrophotometer and a viscometer, respectively, to evaluate how ultrasound treatment influenced these properties.

All experiments were conducted in triplicate to ensure reproducibility. The data were analyzed using statistical software to determine the significance of differences between treatments. Analysis of variance (ANOVA) followed by Tukey's post hoc test was used to compare the effects of different ultrasound parameters on foamability and protein characteristics. To optimize ultrasound parameters, a response surface methodology (RSM) was employed. This involved constructing a model to predict the optimal conditions for maximum foam volume and stability based on the experimental data. The optimized conditions were validated through additional trials to confirm their effectiveness in enhancing foamability.

RESULTS

The application of ultrasound significantly improved the foamability of whey and soy proteins, as evidenced by several key observations. Ultrasound treatment enhanced foam volume, stability, and bubble size distribution for both protein types. For whey protein, ultrasound at a frequency of 40 kHz and an intensity of 70% for 10 minutes yielded the highest foam volume, with a 30% increase compared to untreated controls. Foam stability also improved, with foam retention extending by approximately 25% over a 30-minute period. The average bubble size was reduced, indicating finer and more uniform foam structure, which was confirmed by laser diffraction analysis.

Similarly, ultrasound treatment enhanced soy protein foamability, though the optimal conditions differed slightly from those for whey protein. Treatment at 20 kHz with an intensity of 90% for 15 minutes resulted in a significant increase in foam volume by 40% and improved foam stability by 20%. The bubble size distribution showed a decrease in average bubble size, contributing to a more stable and visually appealing foam structure.

Dynamic light scattering (DLS) and atomic force microscopy (AFM) analyses revealed that ultrasound treatment caused a reduction in protein aggregate size and altered protein surface morphology, which contributed to enhanced foam formation. The solubility and viscosity of the protein solutions were also positively affected, with increased solubility observed in ultrasound-treated samples, suggesting improved protein hydration and reduced aggregation.

Statistical analysis confirmed that the observed improvements in foamability were significant, with optimal ultrasound parameters leading to substantial enhancements over untreated samples. The response surface methodology (RSM) further validated these findings, indicating that specific ultrasound conditions could be tailored to maximize foam properties for both whey and soy proteins. Overall, the results demonstrate that ultrasound is a highly effective method for enhancing the foamability of beverage proteins, offering a practical approach for improving the texture and quality of protein-based beverages. The study provides valuable insights into optimizing ultrasound parameters for various protein types, contributing to advancements in beverage formulation and processing.

DISCUSSION

The results of this study underscore the effectiveness of ultrasound in enhancing the foamability of beverage proteins, revealing its potential as a valuable tool in the beverage industry. The significant improvements in foam volume, stability, and bubble size distribution for both whey and soy proteins highlight the transformative impact of ultrasound treatment. The observed increases in foam volume—30% for whey protein and 40% for soy protein—demonstrate ultrasound's capacity to significantly enhance foam formation, which is crucial for achieving desirable texture and sensory attributes in beverages.

Ultrasound treatment led to a reduction in average bubble size, resulting in finer, more stable foam structures. This effect is attributed to the ultrasound-induced changes in protein structure, such as the disruption of protein aggregates and enhanced protein-protein interactions, which facilitate the formation of smaller and more uniform bubbles. The improved foam stability, with retention times extending by 25% for whey protein and 20% for soy protein, reflects the enhanced ability of ultrasound-treated proteins to maintain foam structure over time.

The analysis of protein characteristics revealed that ultrasound treatment improved protein solubility and altered protein surface morphology, contributing to better foamability. These changes indicate that ultrasound not only affects the physical properties of proteins but also their functional attributes, enhancing their performance as foaming agents.

The study also highlights the need to optimize ultrasound parameters—frequency, intensity, and treatment duration—to achieve the best results for different types of proteins. The optimal conditions identified for whey and soy proteins suggest that tailored ultrasound treatments can maximize foam properties, providing a more effective approach than traditional methods. The response surface methodology (RSM) used to identify these optimal conditions further supports the practical applicability of ultrasound in beverage processing.

CONCLUSION

The study demonstrates that ultrasound treatment significantly enhances the foamability of beverage proteins, including whey and soy proteins, by improving foam volume, stability, and bubble size distribution. Ultrasound effectively increases foam volume by up to 40% and enhances foam stability, providing a more stable and visually appealing foam structure. These improvements are attributed to ultrasound-induced changes in protein structure, which facilitate finer bubble formation and better foam retention.

The optimization of ultrasound parameters, such as frequency, intensity, and treatment duration, was crucial in achieving the best results for different types of proteins. The study's findings suggest that tailored ultrasound treatments can maximize foam properties, offering a practical and efficient method for enhancing protein-based beverages.

Overall, ultrasound presents a promising approach for improving the texture and quality of protein-based beverages, aligning with current industry trends towards advanced processing technologies. The results provide valuable insights into the application of ultrasound in beverage formulation and processing, offering potential benefits for producing high-quality products with enhanced sensory attributes. Future research should continue to explore the broader applications of ultrasound in food and beverage technology, further optimizing its use for various proteins and beverage formulations.

REFERENCE

1. P. Vohra & F. H. Kratzer (1991). Evaluation of soybean meal determines adequacy of heat treatment. Feedstuffs, February 25, 22-28.
2. N. C. Nielsen (1985). Structure of soy proteins. In: A.A. a. W. Altschul, H.L., New protein foods, vol. 5(pp. pp. 27-58). New York: Academic Press.
3. S.Mishra, B.Mann& V.K. Joshi, (2001). Functional improvement of whey protein concentrate on interaction with pectin. Food Hydrocolloids 15 (1),9–15.
4. P. Cayot& D. Lorient (1997). Structure-function relationships of whey proteins. In: Dekker, M. (Ed.), Food Proteins and their Applications, New York, USA.
5. G.Krešic, V. Lelas, A.R. Jambrak, Z. Herceg& S.R.Brncic, (2008). Influence of novel food processing technologies on the rheological and thermophysical properties of whey proteins. Journal of Food Engineering 87 (1), 64–73.
6. D. Knorr, M. Zenker, V. Heinz &D.Lee, (2004). Applications and potential of ultrasonics in food processing. Trends in Food Science & Technology, 15 (5), 261-266.
7. K. D. Martinez & C. Carrera Sanchez (2014). New view to obtain dryer food foams with different polysaccharides and soy protein by high ultrasound. International Journal of Carbohydrate Chemistry, 6pgs.
8. V. P. Ruíz-Henestrosa, C. Sánchez, C. M. d.M.Escobar, J. J. P.Jiménez, F. M. Rodríguez & J.M. R. Patino, (2007). Interfacial and foaming characteristics of soy globulins as a function of pH and ionic strength. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 309(1),202-215.
9. I.Nicorescu, C.Vial, E.Talansier, V.Lechevalier, C.Loisel, D.Della Valle, A.Riaublanc, G.Djelveh, & J.Legrand, (2011). Comparative effect of thermal treatment on the physicochemical properties of whey and egg white protein foams. Food Hydrocolloids, 25(4), 797-808.
10. O. A.Higuera-Barraza, C. L Del Toro-Sanchez, S.Ruiz-Cruz, &E.Márquez-Ríos, (2016). Effects of high-energy ultrasound on the functional properties of proteins. Ultrasonics Sonochemistry, 31, 558-562