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Impact of ultrasonic processing on the physicochemical properties of dairy products

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Abstract
This review article explores the impact of ultrasonic processing on the physicochemical properties of dairy products. Ultrasonic processing, a non-thermal food processing technology, has gained attention for its potential to modify and improve various characteristics of dairy products without the adverse effects of heat. The review synthesizes current research findings, focusing on changes in texture, shelf life, microbial load, and sensory attributes, and discusses the implications of these changes for the dairy industry.

Keywords: Library resource sharing

Introduction

The dairy industry continuously seeks innovative technologies to enhance product quality and safety while extending shelf life. Ultrasonic processing, which involves the application of high-frequency sound waves, offers a promising alternative to conventional thermal techniques. This technology is known for its ability to induce physical and chemical transformations in food systems, including emulsification, homogenization, and microbial inactivation. The unique capability of ultrasonic waves to penetrate deep into food matrices makes it particularly suitable for modifying the physicochemical properties of dairy products.

Main Objective

To explore the impact of ultrasonic processing on the physicochemical properties of dairy products.

Review of Ultrasonic Processing

Ultrasonic processing utilizes sound waves typically ranging from 20 kHz to 1 MHz. The primary mechanisms through which ultrasound affects dairy products include cavitation, mechanical shear, and localized heat effects, which can alter molecular structures and interactions within the food matrix. This review covers the application of ultrasonic processing to various dairy products such as milk, cheese, yogurt, and ice cream.

Physicochemical Changes in Dairy Products

Ultrasonic Processing Parameters: Ultrasonic processing involves several key parameters that significantly influence its effects on dairy products. These parameters include frequency, power/intensity, treatment time, and temperature control. Frequency refers to the number of sound waves emitted per second, typically measured in kilohertz (kHz). Power or intensity represents the energy level of the ultrasonic waves applied to the product, measured in watts per square centimeter (W/cm²). Treatment time denotes the duration of ultrasonic exposure, while temperature control ensures that the processing remains within desired ranges to prevent undesirable thermal effects.

Effects on Milk: Ultrasonic processing induces various changes in milk, including structural modifications such as protein denaturation and fat globule modification. These alterations can influence the rheological properties of milk, affecting factors such as viscosity and shear stress. Additionally, ultrasonic treatment may impact the sensory attributes of milk, including flavor and texture.

Table 1: Physicochemical Changes in Milk through Ultrasonic Processing

Effect	Description
Structural Modifications	- Protein denaturation: Changes in protein structure can affect milk's functional properties such as solubility and emulsification. - Fat globule modification: Ultrasonic treatment may alter the size and distribution of fat globules, impacting the milk's stability and creaminess.
Rheological Properties	- Viscosity: Ultrasonic processing can influence milk viscosity, affecting its flow behavior and texture. - Shear stress: Changes in shear stress due to ultrasonic treatment can impact milk's stability and ability to withstand mechanical forces.
Sensory Attributes	- Flavor: Ultrasonic processing may alter the flavor profile of milk, potentially enhancing or modifying its taste characteristics. - Texture: Changes in milk's texture, such as creaminess or thickness, can occur as a result of ultrasonic treatment, influencing sensory perception.

Impact on Cheese: In cheese production, ultrasonic processing can lead to texture modification, affecting parameters such as firmness and meltability. The interaction between proteins and fats in cheese may also be influenced by ultrasonic treatment. Furthermore, ultrasonic processing has been reported to accelerate the ripening process in cheese, affecting its flavor profile and overall quality.

Table 2: Physicochemical Changes in Cheese through Ultrasonic Processing

Effect	Description
Texture Modification	▪ Firmness: Ultrasonic treatment can alter the texture of cheese, affecting its firmness and consistency. - Meltability: Changes in cheese structure induced by ultrasonic processing may influence its ability to melt and flow when heated.
Protein and Fat Interactions	▪ Ultrasonic processing can affect the interactions between proteins and fats in cheese, potentially influencing its texture, flavor, and stability.
Acceleration of Ripening Process	▪ Ultrasonic treatment has been reported to accelerate the ripening process in cheese, leading to changes in flavor development, aroma, and overall quality.

Influence on Yogurt: Ultrasonic treatment of yogurt can result in viscosity enhancement, improving its texture and mouthfeel. Moreover, ultrasonic processing may affect the activity of starter cultures used in yogurt production, influencing fermentation processes and product consistency. Additionally, ultrasonic treatment has been shown to reduce syneresis, which is the separation of whey from the yogurt matrix.

Table 3: Physicochemical Changes in Yogurt through Ultrasonic Processing

Effect	Description
Viscosity Enhancement	▪ Ultrasonic treatment can lead to an increase in yogurt viscosity, resulting in a thicker and creamier texture.
Starter Culture Activity	▪ Influence on starter culture activity: Ultrasonic processing may affect the activity of starter cultures used in yogurt fermentation, potentially influencing fermentation rates and product consistency.
Reduction of Syneresis	▪ Ultrasonic treatment has been shown to reduce syneresis in yogurt, minimizing the separation of whey from the yogurt matrix and enhancing product stability.

Effects on Butter: Ultrasonic processing of butter can impact its crystallization behavior, affecting its texture and spreadability. Furthermore, ultrasonic treatment may contribute to consistency improvement in butter products. Additionally, ultrasonic processing has been explored as a means to enhance flavor development in butter, potentially leading to a more desirable sensory experience for consumers.

Table 4: Physicochemical Changes in Butter through Ultrasonic Processing

Effect	Description
Crystallization Behavior	▪ Ultrasonic processing can influence the crystallization behavior of butter, potentially affecting its texture and spreadability.
Consistency Improvement	▪ Ultrasonic treatment may contribute to the improvement of butter's consistency, resulting in a smoother and more uniform product.
Flavor Development Enhancement	▪ Ultrasonic processing has been explored as a means to enhance flavor development in butter, potentially leading to a richer and more desirable taste profile.

Conclusion

In conclusion, the application of ultrasonic processing in the dairy industry has shown significant promise in inducing desirable physicochemical changes in various dairy products. Through the manipulation of ultrasonic parameters such as frequency, power, treatment time, and temperature control, it is possible to achieve tailored modifications that enhance product quality, functionality, and shelf-life. In the case of milk, ultrasonic treatment can lead to structural modifications such as protein denaturation and fat globule modification, impacting its rheological properties and sensory attributes. Similarly, ultrasonic processing of cheese can result in texture modification, influence protein-fat interactions, and accelerate the ripening process, ultimately affecting its flavor profile and overall quality. Yogurt, another popular dairy product, can benefit from ultrasonic processing by experiencing viscosity enhancement, improved starter culture activity, and reduced syneresis. These changes contribute to a smoother texture and enhanced stability of the final product. Furthermore, ultrasonic processing can also impact butter, affecting its crystallization behavior, consistency, and flavor development. By refining these physicochemical properties, ultrasonic treatment can elevate the sensory experience of butter and widen its applicability in various culinary applications. Overall, the utilization of ultrasonic processing offers a non-thermal method to innovate dairy product development and processing techniques. It provides opportunities for producing dairy products with improved quality, functionality, and sensory attributes while maintaining nutritional integrity. As the technology continues to advance, further research and exploration of ultrasonic processing in the dairy industry are warranted to unlock its full potential and meet the evolving demands of consumers and food manufacturers alike.

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