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Editorial Open Access

Microbial Inactivation in Foods by Ultrasound

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Abstract

Alternatives to heat treatments for food sanitization are gaining significance due to the increased consumer demand for novel methods that have less deleterious effects on food quality. Ultrasound is an emerging and promising food processing technology to replace conventional methods. Ultrasound has a strong antimicrobial capacity against a spectrum of microorganisms and has been considered as a potential food sanitization approach. There is a wide scope for further research into the use of ultrasound in food processing from both an academic and industrial perspective.

Keywords: Ultrasound; Microbial inactivation; Foodborne pathogen; Food spoilage microorganism; Food safety; Food quality

Editorial

Some novel food sanitization techniques allow better retention of flavor, texture, color, and nutrient of foods than conventional thermal treatments (i.e., pasteurization and ultra-high-temperature (UHT) processing). Among these techniques, ultrasound has attracted considerable interest as a potential food processing approach. Ultrasound refers to pressure waves with a frequency of 20 kHz or more [1]. Ultrasound improves the inactivation of microorganisms, which is attributed to a physical process called acoustic cavitation [2]. Cavitation is the formation, growth, and collapse of gas bubbles in liquid media that can generate a localized mechanical energy [3]. Cavitation can disrupt cellular structure and functional components up to the point of cell lysis through causing severe damage to cell wall [4].

Research has been performed on the inactivation effects of ultrasound on various human pathogens in foods, such as *Salmonella* spp., *Listeria monocytogenes*, *Escherichia coli* O157:H7, *Staphylococcus aureus*, and *Cronobacter sakazakii* [5-8]. Additionally, it has also been widely reported that ultrasound is effective against indigenous food spoilage microorganisms [9-12], such as total aerobic bacteria, yeasts and molds, and lactic acid bacteria. Most published data on the microbial inactivation of ultrasound cannot be compared directly, because authors tested different processing conditions. Several parameters, such as the nature of ultrasonic waves, the exposure time, the treatment temperature, the type of microorganism, the volume of food being processed, and the food composition, can influence the microbial inactivation of ultrasound in foods [2]. Accordingly, treatment conditions should be carefully optimized to obtain maximum killing effects.

It should be noted that the lethal effects of low-power ultrasonic waves on microorganisms in foods have been found to be limited, as a high ultrasonic power is normally required to achieve a high level of microbial reduction [13]. Moreover, a variety of microorganisms are relatively resistant to ultrasound [14]. In the study of Baumann et al. [15], *L. monocytogenes* 10403S was found to be the most ultrasound-resistant strain among all *L. monocytogenes* strains tested. Due to this resistance, the application of ultrasound alone may not decrease the microbial loads sufficiently to satisfy the existing microbiological requirements in food industry. In response, based on the hurdle technology, ultrasound has been applied in combination with other sanitization strategies, such as various energy forms and chemical antimicrobials, to produce synergistic effects. When Ding et al. [11] investigated the combined effects of ultrasound and slightly acidic electrolyzed water on the microbial loads of cherry tomatoes and strawberries, ultrasound enhanced the bactericidal activity of slightly acidic electrolyzed water on indigenous yeasts and molds. Scouten and Beuchat [5] reported that ultrasound had a modest enhancing impact on the effectiveness of calcium hydroxide for killing *S. enterica* and *E. coli* O157:H7 on alfalfa seeds. Similarly, Huang et al. [16] also observed that ultrasound enhanced the bactericidal effect of chlorine dioxide on *S. enterica* and *E. coli* O157:H7 on apples and lettuce. Chen and Zhu [10] demonstrated that the chlorine dioxide treatment with simultaneous ultrasound enhanced the germicidal efficacy against indigenous microorganisms on plums as compared to the sequential application. One plausible explanation for this synergistic effect is that through mechanical waves with high intensity, ultrasound cannot only disrupt microbial cells on fruit surface but also dislodge these cells and force them to be completely exposed to chlorine dioxide [10]. On the other hand, ultrasound may induce the uptake of chlorine dioxide by disturbing or stressing cell membrane, thus reducing the viability of microorganisms [14]. Above findings thus indicate that ultrasound in combination with other methods has great potential to improve the microbial inactivation in foods.

Conventional methods of inactivating microorganisms in foods usually involve thermal treatments [17], which often lead to the reduced sensory quality and the loss of beneficial human nutrients. In contrast, during ultrasound treatment, cavitation is primarily responsible for the killing of microorganisms, which may not affect the overall food quality [2]. In the work of Cao et al. [9], ultrasound was found to be effective in preserving strawberry fruit during storage for 8 d at 5°C. Chen and Zhu [10] reported that ultrasound in conjunction with chlorine dioxide maintained the postharvest storage quality of plum fruit for 60 d at 4°C. Overall, data on the influence of ultrasound on food quality is still scarce and more investigations should thus be conducted to extend the present knowledge. The balance between the desirable and undesirable impacts of ultrasound on food quality will determine its future application in food industry.

In summary, ultrasound is a rapidly growing field of research, which is finding increasing use in food industry. The use of ultrasound in food processing creates novel methodologies, which are complementary to conventional techniques. Ultrasound is effective against microorganisms in foods under some conditions. Several processing and food parameters can affect ultrasound output and its inactivation effect on microorganisms. Many studies have shown that a synergistic antimicrobial effect can be achieved through the combination of ultrasound with other methods. To promote the application of ultrasound in food industry, it is warranted to explore the interactions between acoustic energy and food quality. Efforts should also be made to integrate efficient ultrasound systems to the food processing lines, which will help ensure the production of microbiologically safe and high-quality food products.

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