Applications of Ultrasound in Food Science

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The interaction between (ultra)sound waves and gas nuclei in liquids induces acoustic cavitation, which involves the growth of existing gas nuclei by rectified diffusion/bubble coalescence followed by the inertial collapse of resonance-sized microbubbles. The near adiabatic collapse generates high temperatures within the cavitation bubbles leading to the formation of highly reactive radicals. Acoustic cavitation is also accompanied by a number of physical effects, such as agitation, microstreaming, enhanced mass transport, etc.

High-intensity ultrasound has been increasingly employed in food processing. Ultrasonic extraction of gingerol from ginger, ultrasonic homogenisation of milk and ultrasonic emulsification are some examples that can be highlighted [1,2]. The turbulence associated with acoustic cavitation and streaming is well known to increase mass transfer rates. In a membrane filtration process used in dairy industry, larger particles accumulate on the membrane surface to form a cake layer or become lodged in the membrane pores. Ultrasound can disrupt the cake layer and directly enhance the mass transfer coefficient in this region [3]. Work in our laboratories has shown that mass transport enhancement through sonication can also be important in supercritical fluid extraction processes. The field emission scanning electron micrographs (FESEM) of ginger particles after the completion of the extraction process are shown in Figure 1. The application of ultrasound during the supercritical extraction process led to the breakage of more ginger particles that ultimately resulted in an enhanced extraction yield of gingerol.

Fig. 1: FESEM photographs of ginger particles. Left: After extraction in the absence of ultrasound; Right: after extraction in the presence of ultrasound.

More generally, the turbulence associated with sonication can be used as a source of localised shear forces. We have recently shown such shear forces to be effective in the disruption of whey protein aggregates and in the preparation of fine nanoemulsions. While physical effects generated by acoustic cavitation have been used in many applications, the potential restrictions and/or uses of the chemical effects generated by cavitation have often been overlooked. The presentation will consist of 3 sections: (i) some examples taken from the literature where ultrasound has been used in food processing, (ii) the possible use of OH radicals generated during acoustic cavitation for improving the functionality of specific food ingredients and (iii) ultrasonic processing of whey proteins.

Keywords: Acoustic cavitation, Extraction, Emulsion, Food Science, Dairy industry