Ultrasonic production of skimmed milk

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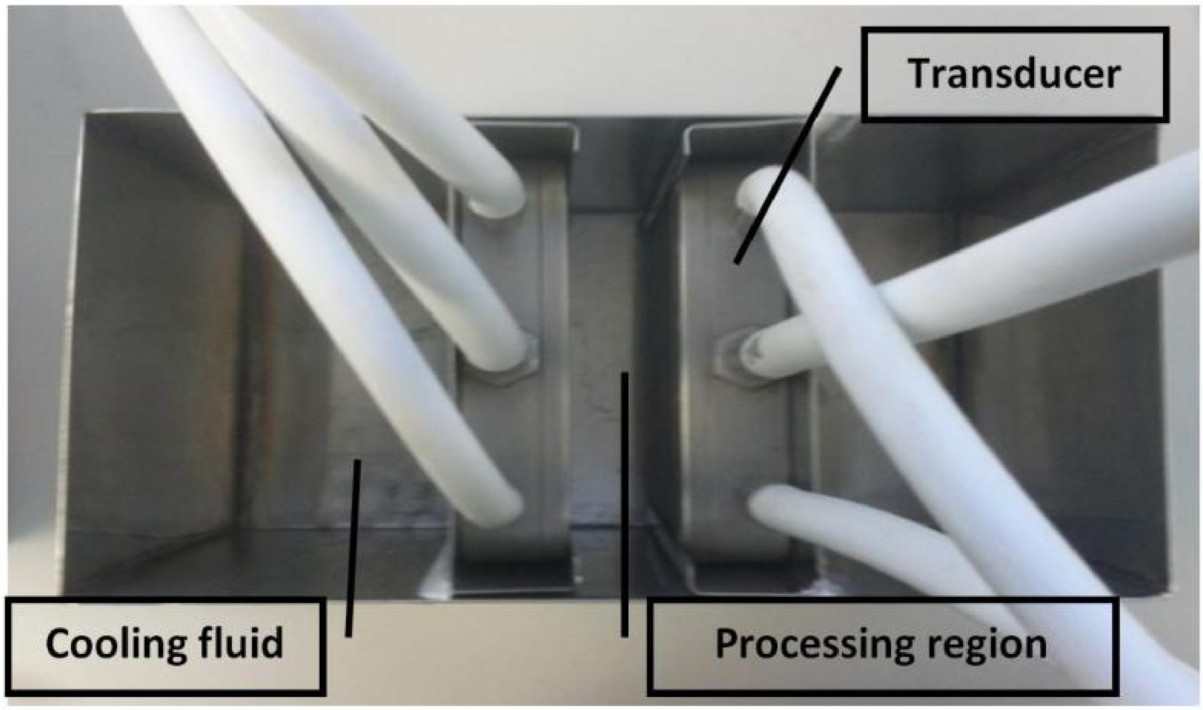

Large-scale ultrasound device for milk fat globules separation is shown. Credit: Thomas Leong/Swinburne University of Technology and CSIRO, Australia

Recently, scientists from Swinburne University of Technology in Australia and the Commonwealth Scientific and Industrial Research Organization (CSIRO) have jointly demonstrated cream separation from natural whole milk at liter-scales for the first time using ultrasonic standing waves—a novel, fast and nondestructive separation technique typically used only in small-scale settings.

At the 169th Meeting of the Acoustical Society of America (ASA), being held May 18-22 2015 in Pittsburgh, Pennsylvania, the researchers will report the key design and effective operating parameters for milk fat separation in batch and continuous systems.

The project, co-funded by the Geoffrey-Gardiner Dairy Foundation and the Australian Research Council, has established a proven ultrasound technique to separate fat globules from milk with high volume throughputs up to 30 liters per hour, opening doors for processing dairy and biomedical particulates on an industrial scale.

"We have successfully established operating conditions and design limitations for the separation of fat from natural whole milk in an ultrasonic liter-scale system," said Thomas Leong, an ultrasound engineer and a postdoctoral researcher from the Faculty of Science, Engineering and Technology at the Swinburne University of Technology. "By tuning system parameters according to acoustic fundamentals, the technique can be used to specifically select milk fat globules of different sizes in the collected fractions, achieving fractionation outcomes desired for a particular dairy product."

The Ultrasonic Separation Technique

According to Leong, when a sound wave is reflected upon itself, the reflected wave can superimpose over the original waves to form an acoustic standing wave. Such waves are characterised by regions of minimum local pressure, where destructive interference occurs at pressure nodes, and regions of high local pressure, where constructive superimposition occurs at pressure antinodes.

When an acoustic standing wave field is sustained in a liquid containing particles, the wave will interact with particles and produce what is known as the primary acoustic radiation force. This force acts on the particles, causing them to move towards either the node or antinode of the standing wave, depending on their density. Positioned thus, the individual particles will then rapidly aggregate into larger entities at the nodes or antinodes.

To date, ultrasonic separation has been mostly applied to small-scale settings, such as microfluidic devices for biomedical applications. Few demonstrations are on volume-scale relevant to industrial application, due to the attenuation of acoustic radiation forces over large distances.

Acoustic Separation of Milk Fat Globules at Liter Scales

To remedy this, Leong and his colleagues have designed a system consisting of two fully-submersible plate transducers placed on either end of a length-tunable, rectangular reaction vessel that can hold up to two liters of milk.

For single-plate operation, one of the plates produces one or two-megahertz ultrasound waves, while the other plate acts as a reflector. For dual-plate operation, both plates were switched on simultaneously, providing greater power to the system and increasing the acoustic radiation forces sustained.

To establish the optimal operation conditions, the researchers tested various design parameters such as power input level, process time, transducer-reflector distance and single or dual transducer set-ups etc.

They found that ultrasound separation makes the top streams of the milk contain a greater concentration of large fat globules (cream), and the bottom streams more small fat globules (skimmed milk), compared to conventional methods.

"These streams can be further fractionated to obtain smaller and larger sized fat globules, which can be used to produce novel dairy products with enhanced properties," Leong said, as dairy studies suggested that cheeses made from milk with higher portion of small fat globules have superior taste and texture, while milk or cream with more large fat globules can lead to tastier butter.

Leong said the ultrasonic separation process only takes about 10 to 20 minutes on a liter scale—much faster than traditional methods of natural fat sedimentation and buoyancy processing, commonly used today for the manufacture of Parmesan cheeses in Northern Italy, which can take more than six hours.

The researchers' next step is to work with small cheese makers to demonstrate the efficacy of the technique in cheese production.

More information: Presentation #3aBA9, "Acoustic separation of milk fat globules - Principles in large scale processing," by Thomas Leong, Linda Johansson, Pablo Juliano and Richard Manasseh will take place on Wednesday, May 20, 2015, at 10:45 AM in the Kings 2 room at the Wyndham Grand Pittsburgh Downtown Hotel. The abstract can be found by searching for the presentation number here: asa2015spring.abstractcentral.com/planner.jsp

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