Sound Solutions: Harnessing Ultrasound Technology in the Fight Against Foodborne Illnesses

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In recent years, there has been an increasing promotion of healthy lifestyles consisting of more fruits, vegetables and unprocessed foods. Such foods offer a bounty of micro and macro nutrients, yet they may also carry harmful pathogens. At the University of Malta, ***Dr Foteini Pavli*** *and her team are pushing boundaries and exploring how fresh produce can be decontaminated using ultrasound technology.*

Dr Foteini Pavli, lecturer and researcher at UM's Department of Food Science, Nutrition and Dietetics, has specialised in food processing and probiotic bacteria throughout her academic career. This specialisation led her to explore innovative, non-thermal methods for food decontamination – most recently, through the 'Ultrasound Technology Combined with Other Disinfection Methods to Enhance Food Safety', or the UltraTech project.

How does ultrasound manage to decontaminate food? Esther Okafor, a Ph.D. student and the lead research support officer for this project, explains that ultrasound works through sound waves passing through a liquid medium. This creates changing pressure levels in the medium, which generates microbubbles. These microbubbles go through an alternating cycle of continuous expansion and compression. The burst of these microbubbles creates pores in a microbial cell membrane, which disrupts and leaks the cellular contents of the microorganism, generates radicals that damage the microbial DNA, and increases the temperature of the suspension medium, thereby contributing to cell permeability. The cumulative effect of all these factors could ultimately lead to microbial cell death.

There are multiple effective food decontamination methods. When it comes to ready-to-eat fresh produce disinfection, chlorine has been used and proven effective. Yet, if current methods are effective, why bother with ultrasound? The answer lies in sustainability.

Okafor explains that while chlorine is a powerful disinfectant for sanitising fresh produce, it leaves behind chemical residues which have raised concerns for 21st century consumers who demand for minimally processed food with little to no chemicals additives.

The UltraTech Team. From left to right: Raquel Camilleri, Dr Foteini Pavli and Esther Okafor.
Photo by Kristov Scicluna

Other methods of decontamination, such as heat-based methods, reduce the vitamin and possibly the minera content of the produce. Conversely, ultrasound does not produce any residues and, as a non-thermal technology, minimises the loss of nutritional content – a double win.

BEYOND THE SURFACE

Okafor explains that 'fruits and vegetables are often consumed raw, and when we look at food recalls over the years, many involve these fresh products.' She also points out that one must consider vulnerable populations, such as the elderly, who favour more convenient and healthier food to consume. Such populations are at an even greater risk of having complications in case of food poisoning due to various comorbidities and weaker immune systems, highlighting the importance of food decontamination.

'The barriers to food safety are multifaceted,' Okafor explains. One such barrier is the complex global food supply system. For instance, food imports from countries with weaker food safety systems could have a negative impact on a country with a stronger food safety system during recalls or food-borne outbreaks.

Okafor also adds that fresh produce is sometimes contaminated not solely by one microorganism but rather by a plethora of microorganisms. 'These organisms are not just waiting around to get killed,' Okafor jokingly remarks. They are constantly evolving, making it increasingly difficult to eliminate them through their survival systems.

Pavli comments that climate change also has a role in food safety, due to its adverse effects on crop growth and storage conditions. Pavli remarks that Europe has a strong food safety culture, and the aim of the UltraTech project is not to alarm people about consuming raw fresh produce but rather to acknowledge the possibility of contaminated food and address the need to search for more effective and sustainable decontamination methods.

AN INTERDISCIPLINARY LAYER

Alongside Pavli and Okafor, Raquel Camilleri, a master's student at UM, brings an interesting dynamic to the mix. Having a B.Sc. in Applied Food and Nutritional Sciences and a Postgraduate Diploma in Dietetics, she explains that nutrition and food science are closely related. 'Many vulnerable groups, such as the elderly, cancer patients and children, benefit from safer, less processed foods. I meet multiple patients seeking minimally processed options,' she remarks.

Unlike other decontamination methods, such as thermal pasteurisation or chemical disinfectants, ultrasound used in this context is generally not considered a traditional food processing treatment. This is because ultrasound applied for microbial inactivation on fresh produce acts as a mild, non-thermal intervention targeting surface microbes without fundamentally altering the food's physical or

Top and bottom left: Ultrasound treatment on fresh-cut kale.

Bottom right: Assessing the colour changes of a cherry tomato after ultrasound treatment.

Photos by Kristov Scicluna

chemical properties, such as texture, flavour, or nutritional content. Using novel technologies like ultrasound could especially appeal to vulnerable populations, if proven effective.

Furthermore, this research perfectly exemplifies integration between food science, nutrition, and dietetics. UM's Department of Food Science, Nutrition and Dietetics uniquely offers a 4-year professional undergraduate degree, where students can focus on a specific stream in their fourth year of studies. Bringing together all these disciplines offers a fresh and innovative approach, encouraging collaboration across fields to better connect research with everyday health and wellness. Camilleri says that at the end of the day, the goal of the researchers, despite their specific background, is common – to produce food that is safe, healthy and sustainable.

MULTI-HURDLE APPROACHES (AND MORE HURDLES AHEAD)

On its own, ultrasound is not sufficient as a means of decontamination to produce safe food that meets the industrial benchmark. Okafor explains that to boost effectiveness, combination strategies, called multi-hurdle approaches, are used. For example, ultrasound may be combined with natural antimicrobial compounds (like essential oils, such as rosemary and oregano) or with probiotic bacteria. These bacteria are a method of biopreservation, using beneficial microbes or their metabolites to extend shelf life and enhance food safety. These combinations aim to maximise safety while maintaining quality.

Existing studies have shown that essential oils used together with ultrasound provide comparable inactivation rates to those achieved by using chlorine. While results in the literature vary, the clear benefit is that essential oils leave behind no toxic chemical residues, making this approach far more environmentally friendly.

Pavli notes that currently, the main barriers to the application of ultrasound technologies are inconsistent microbial reductions and scalability issues at the industrial scale. Okafor added further that 'even if something doesn't work, it helps future researchers. It shows them what's already been tested'.

WHAT IS NEXT?

Nonetheless, other barriers still remain. Maintaining the desired taste, texture, and appearance of food is paramount. Small sensory changes – like softened texture or discolouration – can turn consumers away. With limited studies so far on fresh produce, the UltraTech research team is experimenting to optimise ultrasound settings and reduce negative changes. Pavli points out that through the synergistic action of technologies, the research project's aim is to use milder ultrasound treatments and avoid adverse changes.

Pavli explains that more research is needed to apply the technique to different products and study its effects on texture and sensory qualities. She goes on further to say that ultrasound will likely see developments in the food industry, especially for purposes like fermentation, homogenisation, and extraction. With regards to decontamination, more research, time, and funding are needed before it is commercially viable.

Ultimately, Pavli explains that the aim of this research goes beyond simply studying food decontamination. The team's vision is to develop smarter, cleaner technologies that safeguard both human health and the environment. UltraTech serves as a reminder that when science is guided by sustainability, it can deliver sound solutions that benefit generations to come.

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