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Review Article
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Thermosonication as an Upcoming Technology in the Dairy Industry: An Overview

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Abstract

Ultrasound waves are longitudinal sound waves of frequency of 20 kHz or more. As low amplitude ultrasonic waves do not significantly modify the material under examination, they can be used to analyse the material. However, high amplitude ultrasonic waves can be used to process food as they have the capacity to alter the food material by cavitation. Nowadays ultrasound processing is increasingly being used in the dairy industry. The use of high amplitude ultrasound by itself may not be effective in in bringing about the desired processing effects. Hence, it can be coupled with pressure or heat or both to get the desired results. Thermosonication involves the simultaneous use of low frequency ultrasound waves (20 kHz) along with heat; and the both together have some synergistic effect. When heat and ultrasound is used together, the process temperature is considerably reduced compared to the conventional heating process, making it a green and economical technology as less energy is consumed; this in turn makes it a cost-efficient process. If thermosonication is seen to bring about the desired effects in milk, then it can be used as a commercial method to treat and homogenize milk in the future.

Keywords: Ultrasound; Thermosonication; Pasteurization; Homogenization

Introduction

Commercially milk and milk products like butter, yogurt, cheese, cream etc. are treated by the conventional pasteurization method in which the milk needs to be held at high temperatures for a certain period to control the microbial growth. However, heat treatment is not effective against all microbes and also may bring about certain loss in nutrient and flavour [1]. A study by Michael P. Doyle and his team [2] has shown that *Listeria monocytogenes* can survive the minimum high-temperature, short-time heat treatment (71.7°C, 15 s) that is the U.S. Food and Drug Administration requirement to pasteurize milk. The high temperature also causes damage to the nutritive and organoleptic values of food. The structure and texture is deteriorated due to new compounds (toxic) formed as a result of temperature catalysed reactions or modification of the existing macro molecules [3]. The heat generated during pasteurization brings about some chemical changes like denaturation of protein, destruction of vitamin, occurrence of Maillard reaction and lysinoalanine production [4]. The proteinaceous nature of the bioactive compounds of milk may be destroyed by the heat employed during pasteurization, requiring novel technologies for treating milk [5]. Separation of fat from milk using centrifugal separators is an energy intensive process. Also, a lot of water is required to clean the centrifugators. The use of ultrasound in separating dairy fat is being studied as that require less energy and also the dependency on water to clean the equipment will be reduced [6]. Consumer demand of energy efficient, higher quality products with unaltered nutritional and sensory qualities, devoid of artificial additives has lead researchers venture out for novel processing techniques [7,8].

Hence, alternative and novel techniques are increasingly being studied to save time and processing costs, although retaining the nutritional attributes and not compromising with the product safety. Use of ultrasound can be one such non-thermal alternative of pasteurisation to treat food products. The research on ultrasound in food processing and characterizing is high in demand now because of its non-invasive, non-destructive, rapid and precise nature [9]. Ultrasound can be used in different processes like ultrafiltration, extraction, homogenization, crystallization, emulsification, drying etc. The use of ultrasound also increases the process efficiency, improves shelf life and also improves the functional properties of products [10].

Summary

Ultrasound waves are longitudinal sound waves of frequency of 20 kHz or more [11]. As low amplitude ultrasonic waves does not significantly modify the material under examination and so they can be used to analyse the material. However, high amplitude ultrasonic waves can be used to process food as they have the capacity to alter the food material by cavitation. In previous studies both low and high frequency ultrasound waves were tested to see the extent of inactivation of microbes. It was found that low frequency ultrasound waves (20-100 kHz) are more effective in bringing about the inactivation through cavitation. It has been observed that ultrasound was more effective in destroying the gram negative bacteria (*Enterobacter aerogenes*) than gram positive bacteria (*Staphylococcus spp*). The latter is not much affected due to the resistance from the capsules [12]. The use of ultrasound by itself may not be effective in destroying all the microbes in food. Hence, it can be coupled with pressure or heat or both to get the desired results [13].

Thermosonication, involves the simultaneous use of low frequency ultrasound waves (20 kHz) along with heat; and the both together have some synergistic effect. Thermosonication has been found to be more effective than thermal treatment alone in reducing Bacillus cerus spores in rice porridge and required 20-30°C lower temperature for the same spore inactivation [14]. A study revealed that at 70°C and 75.5°C, ultrasonic homogenization obtains a better particle distribution of fat globules than with no heat [15]. Thus, thermosonication can be used both for inactivation of microbes and homogenisation of milk reducing the processing costs considerably. When heat and ultrasound is used together, the process temperature is considerably reduced than the conventional heating process, making it a green and economical technology as less energy is consumed, which in turn makes it cost-efficient [16].

Proteases are heat stable; they just get inactivated during the heat treatment of pasteurization of milk. Hence, the shelf-life of pasteurized milk decreases as these proteases brings about gelation and bitterness in the due course of time. The effect of ultrasound combined with heat treatment is being studied to check the protease activity in processed milk; in order to increase its shelf life [17]. Yogurts made from thermosonicated milk were found to have improved consistency, texture, gel strength, viscosity and water holding capacity compared to yogurts prepared from pasteurized milk, also a drop in fermentation time of around 40% was seen [18,19]. The heat stability and gelling properties of whey proteins was improved when sonication was combined with heat treatment [20]. One of the concerns in using ultrasound in dairy is: ultrasound processing of milk may lead to the formation of volatiles due to lipid oxidation in milk. However, these volatiles can be avoided by optimising the process parameters including frequency, power levels, processing time, temperature of the milk sample, and fat content of milk [21].

Conclusion

Data on effects of ultrasound treatment on the sensory properties of milk are limited. More research is required to completely shift to ultrasonic treatment from conventional ones at the industrial level. The experimental parameters of temperature, amplitude and time should be obtained for milk and different products to get the optimal results. Thermosonication can prove to be a cost efficient technology as the process temperature is reduced due to the use of ultrasonication when compared to the conventional heating techniques. However, more pilot studies are needed to be taken up to understand the commercial feasibility of the process. If thermosonication is seen to bring about the desired effects in milk, then it can be used as a commercial method to treat and homogenize milk in the future.

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