Effect of Photosonication on Food: A Mini Review of Recent Advances

Kuriakose, S., Krishnan, A., Rawson, A.

Abstract

There is a high demand of minimally processed food products with fresh like characteristics. Photosonication is a novel hurdle technology which utilizes a combined treatment of ultrasound and UV light and which has shown potential in achieving 5 log and 12 log reduction in juices. This review analyses the changes which occur due to photosonication on food products.

Keywords: Photosonication, Hurdle technology, Juices, Quality.

Introduction

As the demand for processed food has increased in our day to day life it is necessary to improve the shelf life of food to the maximum. Thermal methods are generally used for the preservation of the food. Thermal treatment involves high heat treatment which leads to destruction of microorganisms and hence assures long shelf life of the product. However it also causes undesirable changes in flavour, colour, texture and nutritional components of food. Recently many novel non-thermal technologies have emerged for processing of food, such that they not only preserve the food with better quality attributes but have also been reported to be more energy efficient (Ortegas-Rivas E et al.; 2006).

Ultraviolet light (UV) treatment of food is one such techniques of food preservation, as it has been reported to have germicidal effect (Guerrero-Beltran & Barbosa-Canovas, 2006). In UV light processing, radiation is obtained from an electromagnetic spectrum’s UV region. UV treatment is a disinfection method (Farid et al., 2001) that can be a source for pasteurization of liquids or disinfection of solid foods as an alternative technology. Morris et al. (2007) suggested that an UV exposure of 400 J/m² in all parts of the product must be obtained to achieve microbiological inactivation. UV is applied in synergy with chemical sterilants on package material surfaces to increase the microbicidal effect and to reduce the residual chemicals (Brody, 2005).

Power ultrasound is another emerging non-thermal technology. It is defined as sound waves having frequency that exceeds the hearing limit of the human ear (~20 kHz) which in turn produces bactericidal effect and causes enzymatic inactivation. It is more effective when combined with heat (thermosonication), pressure (manosonication), light (photosonication) and with all the three i.e., heat, pressure and sound (manothermosonication).

However there are some limitations of these technologies, in case of UV, it’s only a surface decontamination, as it cannot penetrate the sample food material; hence it finds its application in purification of water. Similarly power ultrasound is a mild treatment when used as standalone technology and can only achieve 5 log reductions of microorganisms.
ultrasound when used together can have high microbicidal effect on liquid food, like juices, milk etc. A photosonication technique using ultrasound and ultraviolet radiation together was first described by Toy & Carter (1990). The technique was not investigated except for the recent study done by Sengul et al. (2011), figure1. Photosonication is a combined effect of simultaneously applied ultrasound and ultraviolet irradiation to avoid the undesirable effects of heat (Char et al., 2010; Milly et al., 2007). In ultrasound process, the main mechanism of action is cavitation, it leads to the formation of pores outside the cell membrane, disruption of cell structures and breakage of cells (Bermudez-Aguirre & Barbosa-Canovas, 2006; Ugarte-Romero et al., 2006). In addition, the action of ultrasound in an aqueous medium generates localized heating and free radicals which also leads to bacterial inactivation (Butz & Tauscher, 2002; Fellows, 2000). The ultraviolet light acts as an antimicrobial agent as it leads to the DNA damage of microorganism (Rame et al., 1997). Thus the cavitation caused by ultrasound followed by the penetration of UV rays can effectively inactivate the microorganisms and hence photosonication can be preferred over other thermal and non-thermal treatments to preserve food. Moreover, combining two or more non-thermal processes can allow the use of lower individual treatment intensities (Ross et al., 2003).

The effect of photosonication treatment on microbial inactivation in liquid food

Few studies have been conducted on liquid food for studying the effect of photosonication on the microbial inactivation. A study was done by Sengul et al., 2011 on the effect of photosonication treatment on inactivation of total and coliform bacteria in milk. The proximal analysis and the initial microbial load of raw cows’ milk for total and coliform bacteria was 8.6 and 5.31 log cfu ml$^{-1}$ cycles, respectively.

The initial microbial load for total aerobic mesophilic bacteria and coliform bacteria was 8.605 and 5.31 log (cfu/ml) cycles, respectively. During 15 min treatment, photosonication process reduced total aerobic mesophilic bacteria by 4.79 log cycles and coliform bacteria by 5.31 log cycles while sonication resulted in reduction of total aerobic mesophilic bacteria by 1.31 log cycles and coliform bacteria by 4.01 log cycles After 30 min of thermal treatment, the initial microbial load for total aerobic mesophilic bacteria (8.605 log cfu ml$^{-1}$) and coliform bacteria (5.31 log cfu ml$^{-1}$) of raw milk was reduced by 3.28 and 5.31 log cycles, respectively. Munkacsi and Elhami (1976) found that the treatment of milk by ultrasound resulted in the inactivation of 93% of coliforms, and the treatment of UV for 20 s after sonication increased lethality of coliforms by 99%.. Compared to thermal treatment of 30 min, photosonication process was more effective in terms of total aerobic mesophilic bacteria inactivation within 15 min and a similar total microbial reduction for coliform bacteria was obtained at photosonication process of 9 min.

Similarly Munoz et al. (2011). Reported that high intensity light pulse in combination with thermosonication showed a significant inactivation of e coli in orange juice. Furthermore they also studied the sequence in which the treatment of the sample is conducted for the microbial efficacy. Munoz et al (2011) observed that the combination of high intensity light pulse as a first hurdle followed by thermosonication or vice versa led to significant reduction in ecoli in orange juice however there was no significant effect due to change in sequence of processing technology. Gabriel (2015) reported that the combined treatment of the juice with UV and ultrasound resulted in greater inactivation of EcoliO157:H7 in apple and orange juice. However the inactivation was higher in case of apple juice compared to in orange juice which was attributed to the opaque character of the juices in comparison, thus limiting the effect of UV radiation. Ferrario and Guerrero (2016) reported the combined treatment of pulsed light and ultrasound led to delayed yeast and mold recovery and prevented browning development during storage of apple juice. They also reported that photosonication led to inactivation of Escherichia coli ATCC 35218, Salmonella Enteritidis MA44 and Saccharomyces cerevisiae KE 162 and indigenous flora in apple juice.

Tsenter et al. (2015) reported that the combination of high frequency ultrasound and UV was effective in achieving significant reduction in Bacillus cereus cells and spores. This phenomena was explained by the fact that ultrasound treatment led to the formation of OH ions in aqueous aerosol leading to oxidation and damage of cells and spores and treatment with UV led to complete inactivation of these microorganisms.
In other words, the possibility of decreasing the process intensity by combining two or more treatments to preserve food quality appears promising (Marquenie et al., 2002). Besides, the combination of ultrasound and UV light was more efficient with respect to treatment time and energy consumption compared to either treatment individually. Thus this study proves that the combine treatment of ultrasound and light inactivate the TOTAL AEROBIC MESOPHILIC BACTERIA and coliform bacteria effectively than when it was treated individually.

**The effect of photosonication treatment on quality of liquid food**

Baslar & Ertugay (2012) reported that total phenolic loss was between 21% and 26% from heat treatment (1 min at 90 °C), where as it was 15% for photosonication processes. They also reported that the temperature change during the photosonication treatment significantly affected the total phenol content in apple juice. The effect of UV light in photosonication was not observed to be significant and the reason for the phenolic loss was associated with acoustic cavitations (Baslar & Ertuga, 2012). This phenomenon may be due to the fact that acoustic cavitations lead to the formation of free radicals (Weiss et al., 2011), which in turn may degrade the total phenolic components.

Baslar & Ertugay (2012) reported a significant change in the color index following photosonication of apple juice. They reported that a clear increase in the L value and b values was observed, a values approached zero from slightly negative values of fresh juice following photosonication. They hypothesized that the main reason for colour change could be due to the disintegration of enzymatic browning compounds by acoustic cavitations and UV light. No changes in the pH values were reported in apple juice following photosonication. However an increase in °Brix was observed which was attributed to evaporation, but other processing conditions did not affect the Brix value ($p < 0.05$).

Munoz et al. (2012) reported that there was a significant effect on the quality of apple juice in terms of changes color, non-enzymatic browning and antioxidant activity when the sequence of the treatment was varied from thermosonication followed by pulsed light treatment or vice versa. However Caminiti et al. (2011) showed that pulsed light followed by manothermosonication induced no significant change ($P \geq 0.05$) in the non-enzymatic browning and antioxidant activity of a blend of apple and cranberry juice compared to an untreated control. However, “noticeable” ($\Delta E=4.88$) colour changes were detected as a result of the significant decrease observed in a and b colour values. No change was observed in the samples treated by Pulsed Light alone, so the authors concluded that only Manothermosonication treatment was responsible for the colour differences measured.

In general it could be summarized that the combination of UV and ultrasound had significant affect on the quality of the juices. The main reason being that ultrasound leads to the formation of free radicals which may deteriorate the quality of juice due to oxidation of colored pigments, hence leading to a change in color of the juice sample. Moreover it has a scope to reducing the energy consumption compared to conventional thermal treatment.

**Conclusion and Future Scope**

Photosonication is an emerging technology for the processing of liquid food such as juice including apple, cranberry, orange etc and milk. And it has been proved successfully in achieving a pasteurized or sterilized condition in the liquid food. Moreover the quality has also been show to be retained with an added advantage of lower energy consumption. However further research is needed in this line and preferable in a continuous processing system, which can have a scope to be used in the food industry in future.

**References**


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Author’s details

1Indian Institute of Crop Processing Technology, Thanjavur, TN, India

2Kerala Agricultural University, Tavanur, Kl, India

*Corresponding author email: ashishrawson@gmail.com

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