Investigating the Usage of Manothermosonication Nonthermal Energy in Food Processing

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ABSTRACT: Today, methods, damaging lesser the quality of foods and their safety, are used including ultrasound waves, presonication, manosonication, thermonosonation, postsonication, and manothermosonication. Manothermosonication is the combination of ultrasound with moderate temperature and pressure, applicable for milk and fruit juices. The mortality of this procedure is 6-30 times greater than the heat treatment with the same temperature, and its effects depend on the intensity, scope, and duration of exposure to the environmental radiation. In this method, ultrasound causes cavitation, thus pH, the application of pressure, temperature, water molecules break down, and producing reactive radicals which can react with specific molecules and leads to the denaturation of the enzymes and sensitivity of bacteria to heat, and the pressure increases cavitation. Research on E.Coli bacteria showed that considering the mortality of thermosonication and manothermosonication on this type of bacteria, mortality of manothermosonication is more than ultrasound waves and manosonication. It also increases with pH decrease. This procedure inactivates protease and lipase enzymes making quality problems in milk and the pectin methyl esterase enzyme that cause the breakdown of pectin and juice opacity, highly resistant to heat, without harm to its sensorial and nutritional properties. Therefore, this method can be used as an efficient non-thermal method in food industry.

Keywords: ultrasound waves, presonication, thermonosonation, postsonication, manosonication, manothermosonication

INTRODUCTION

Food preservation is one of the oldest technologies used by human beings. Desiccation, salting down, and freezing for food preservation are thousands of years old, but these traditional methods and many other techniques that have been developed and used over the last century are always being modified and developed. Now, one of the most important methods of food preservation is heating. Heat with its destructive effects on enzymes and microorganisms supplies health and long-term preservation of food. But, heat has different effects on food such as reduction in the nutritional value and drastic changes in organoleptic properties of food (Feng et al., 2011). There is no way to replace the heat, but new techniques have been developed in which heat is combined with other methods that increase the mortality effect of heat with intensity and shorter time on microorganisms and enzymes, called food preservation via synthetic processes. Today, the combination of heat with other technologies is used including the combination of ultrasound waves, heat, or pressure or both (Kuldiloke, 2002).

Ultrasound waves

Ultrasound waves are waves with a frequency of over 18 kHz whose frequency range is further than human hearing range (Knorr et al., 2010). Ultrasound waves with high and low-intensity are used in the food industry. Ultrasound waves of low intensity are used as the analytical method in providing data on chemical and physical properties of food. After disruption of waves, the physical and chemical properties of nutrients do not change; that is why this technique is called non-destructive method that can be used in measuring thickness, foreign object detection, measuring flow rate, determining the components, particle sizes, etc. while high-intensity ultrasound waves applied in high power are used as a tool to change the characteristics of foods such as
homogenization, cleaning, sterilizing, heating, emulsification, and inhibiting the activity of enzymes and microbes (Knorr et al., 2010). For the inactivation of enzymes by ultrasound waves certain conditions are needed. Enzymes such as catalase are not inactivated during the ultrasound radiation at low temperatures. Invertase in yeast is relatively resistant and is slightly inactivated after prolonged exposure to very low concentrations. Pepsin is very resistant unless radiation happens in very dilute solutions. Ribonuclease is not inactivated by radiation in the presence of oxygen or hydrogen. For inactivation effects, long periods of radiation in the presence of oxygen are required. If in the presence of ultrasound wave, hydrogen replaces by oxygen, or if there are antioxidants, enzymatic inactivation is greatly reduced. Hybrid processes to increase the effectiveness of ultrasound is effective for microbial and enzyme inactivation (Dolatowski et al., 2007).

Ultrasound equipment

The most important parts of ultrasound equipments include electricity generator, transformer (the creator of the wave), and wave transmission part of the device to the sample. The most important part of equipments for creating sound waves is the transformer. Ultrasonic transformers are designed to transform mechanical or electrical energy into sound energy (Fellows, 2000).

Presonication

The product is pre-treated by ultrasound before being subjected to pressure or temperature. This can reduce resistance of enzymes and microorganisms resistant to heat and pressure (Kuldiloke, 2002).

Thermosonication

In thermosonication, the product is exposed to ultrasound waves and moderate heat. In this technique, the temperature should be controlled. Using this method, the temperature declines as much as 25 to 50%. After treatment with this method, change in color and vitamin C are minimized (Kuldiloke, 2002). During thermosonication, with increasing temperature, the mortality effect of on the vegetative cells increases, but it will not be effective for the inactivation of spores.

Postsonication

In this procedure, the product, before it is subjected to ultrasound waves, must be heat-treated or subjected to pressure. Of course, this technique is not well known and there is no experimental information (Kuldiloke, 2002).

Manosonication

In this method, enzymes and microorganisms’ inactivation is made possible by combining ultrasound waves and medium pressure of about 100-300KPa at low temperature (Kuldiloke, 2002).

Manothermosonication

In 1992, to perceive the thermosonication effect, a thermistor was designed and constructed under pressure. Using this device, heat combination methods and pressure sonication were applied in a wide range of temperatures (up to 140 °C), pressures (up to 1000 kPa), sonication intensity (up to 340W, 145μm), and oscillation at a fixed frequency of 20 kHz. Manothermosonication is in fact the combination of ultrasound with average temperature and pressure for inactivation of microorganisms and enzymes described by a researcher named Sala. The objectives of this approach can be using very low heat, improving nutritional value, improving organoleptic properties, and increasing product safety (Feng et al., 2011). Studies show that mortality of manothermosonication is 6-30 times greater than heat treatment with the same temperature and is more effective than bacteria spores for yeasts (Fellows, 2000). Manothermosonication effect depends on the intensity and range of ultrasound, ultrasound exposure time, temperature, pressure application, and pH of the environment. Manothermosonication is mostly used for liquid foods, especially milk and fruit juice, and it is useful to inactivate peroxidase, lipoxygenase, lipase, and protease in dairies and pectin methyl esterase in tomato and orange juice (Demirdöven et al., 2008). The death flow due to manothermosonication is logarithmic, so it is the same as heat treatment (Fellows, 2000).

Ultrasonic wave through cavitation (bubble burst) in food causes inactivity in enzymes and microorganisms. Ultrasound waves’ diffusion in the liquid environment creates bubbles. The bubbles grow to a critical stage and then burst; as a result, the severe cavitation breaks water molecules and produces highly reactive radicals which can react with specific molecules, and also mechanical stress which is caused by the shock of waves due to the bubbles burst can break large molecules or particles, contributing to the denaturation of enzymes.
Regarding the bacteria, this method releases polypeptides and dipicolinic acid from the spores, making the bacteria sensitive to heat. The pressure increase also increases the cavitation threshold (Demirdöven et al., 2008).

**Manothermosonication operation (MTS)**

Figure 1 is a small system of MTS which is made of an ultrasound generator installed in a reactor with an internal diameter of 40mm and a volume of 50ml and the frequency of the generator is 20KHZ. The reactor temperature is controlled by the water that revolves around the reactor. The pressure is adjusted manually by a nitrogen supply, and then the bacterium is injected by a syringe into the reactor (Lee et al., 2009).

![Manothermosonication system (MTS)](image)

**Manothermosonication effect on microorganisms**

Researchers have investigated the effect of ultrasound waves, TS, MS, and MTS (20KHz, range of 124 μm), at 40, 47, 54, and 61°C, at a pressure of 100, 300, 400, and 500kPa on the inactivation of *E.Coli* bacteria in buffer with pH = 7. The results revealed that the rate of inactivation of *E.Coli* in TS and MTS methods is greater than the ultrasound waves and MS procedures (Lee et al., 2009). In another experiment, it was found that inactivation of *E.Coli* bacteria by MTS increases with pH reduction (Lee et al., 2009). In another study, the fatality rate of manothermosonication on *Escherichia coli* was studied on apple and carrot juice. They found that MTS could reduce the amount of this microorganism by 5 log during the preservation time and has a good performance in inactivation of the microorganism compared with heat HTST (Kahraman, 2015).

**Manothermosonication effect on enzymes**

In many food products such as citrus juices, tomato paste, fruit juices, dairy products, dried or frozen products, enzymes must be inactivated. The heat-resistant enzyme in lemon and citrus is pectin esterase; decomposing pectin; as a result, the juice becomes opaque. Pectin esterase is as an indicator of pasteurization in the juice industry because it is the most resistant enzyme to heat. Ultrasound waves cannot alone inactivate the heat-resistant pectin esterase, even if radiate for a long time. The combination of ultrasound and heat (thermosonication) slightly reduces the activity of this enzyme, while manothermosonication inactivates pectin esterase significantly in pressure of about 100-300kPa and temperature below 100 °C (Kuldiöke, 2002). Lee et al. (2005) examined the effect of manothermosonication on properties of orange juice during storage at + 4°C. They found that the treatment did not break up the pulp and caused less degradation of ascorbic acid in comparison with the heated sample during the preservation time. Enzymes such as lipase and protease, agent in quality problems of milk UHT and dairy products, waste away by MTS treatment (for protease 20kHz, 145μm range and 650kPa, for
lipase 117μm range, 450 kPa) 10 times greater than heat treatment. MTS can be a viable alternative to heat treatment in products such as milk or inert products (Vercet et al., 1997).

CONCLUSION

Using new and combinational processes such as ultrasound waves, presonication, manasonication, thermosonication, postsonication, and manothermosonication, in addition to ensuring the food safety, the quality is also maintained. Manothermosonication is the combination of ultrasound with moderate temperature and pressure, mostly applicable for milk and fruit juices. It is useful for inactivation of peroxidase, lipooxygenase, lipase, and protease in milk and pectin methyl esterase in tomato and orange juice. This method is more effective for the yeast compared to bacteria spores. This method, increasing the fatality power of heat treatment combined with ultrasonication pressure, reduces heat intensity, thus provides health and safety of food and improves the organoleptic and nutritional quality. It can therefore be applicable as a beneficial alternative method replaceable with direct thermal treatments.

REFERENCES

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