J. Appl. Environ. Biol. Sci., 4(1s)82-86, 2014

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

Ultrasound Effect on the Preservation of Dairy Products

Yasaman Esmaili*

MA student, Food Science and Technology, Fasa University, Fasa, Iran

ABSTRACT

Ultrasound has substantial advantages over other methods of analysis and the control techniques for processing and immunizing food. The application of ultrasound in food industry is related to quality control of food, process control, homogenization, cleaning, sterilization, etc. However, this method like all methods has its advantages and disadvantages: the generation of free radicals in food (which causes poor taste in some fruit juices) and fatty foods are among some of the method's disadvantages. A major advantage of this method is its non-destructive feature in addition to not being time consuming. One of the most important applications of ultrasound is in dairy industry and a major application of it is to inactivate microorganisms and ultrasonic homogenization. The significant effect of ultrasound on microorganisms is due to the physical stress of rapid alternating and the greatest effect of it is when ultrasound is applied along with other methods such as ultrasound combined with heat and pressure which is called "manothermosonication". Ultrasonic homogenization is based on cavitations that lead to fat globules shrinkage.
KEYWORDS: ultrasound, dairy industry, homogenization, ultrasonic

1. INTRODUCTION

The consumers are now demanding the performance of least processes and a special emphasis is on the preservation of quality and sensory characteristics; therefore, non-thermal food processing and preservation are crucial. One of the current and important methods of non-thermal food processing and preservation is the application of ultrasound waves (Demirdoven & Baysal, 2008).Man is capable of hearing sound waves with 20 to 20000 cycles per second frequency. Sound waves with lower 20 cycles per second frequency are called "Infrasound" and a set of mechanical waves with frequencies over the range of human hearing (i.e., 20 KHz) are called "Ultrasonic" waves (Schroeder, 2007).

Ultrasound techniques are used in both modification and analysis in food industry. Other applications of ultrasound waves in foods refer to inactivation of enzymes and bacteria. Despite the fact that investigation is not yet completed, the studies indicated that the combination of ultrasound with pressure and heat seems to have a bright future (Demirdoven & Baysal, 2008).

2. LITERATURE REVIEW

The term "ultrasound" is derived from the Latin term of Ultra meaning superior and sound meaning voice. In 1927, the article of "the chemical effects of acoustic waves with high frequency: A preliminary study" was published that stated the improvements in application of ultrasound power for a wide range of processes including cleaning the surface and emulsification (Richards & Loomis, 1927). In 1960, the application of ultrasound waves in processed products was well received and the improvements are still in progress (Abramov, 1998).

Table 1- Some application of ultrasound in food processing

Some applications of ultrasound in food processing
Mechanical effects
Crystalline fat, sugar, etc.
Gas extraction
Demolition of foams
Extraction of food flavoring agent
Filtration and drying
Freezing
Mixing and homogenization
Deposition of powders suspended in air
Meat tenderization
Chemical and biochemical effect
Bacteria function
Living cells modification
Sterilization of equipment

*** Corresponding Author:** Yasaman Esmaili, MA student, Food Science and Technology, Fasa University, Fasa, Iran

Using ultrasound in food industry is divided into two types:

1. Ultrasound application with high intensity
2. Ultrasound application with low intensity

Waves with high intensity: Ultrasound waves with high intensity in which high power is applied, are mainly used as a tool to change food properties such as homogenization, cleaning, sterilization emulsification, chemical reaction acceleration, sterilization, inhibition of enzymes and microbes, cells destruction, intensifying oxidation reactions, meat modification, crystallization reformation, increasing liquor preservation, water reduction, etc. Incompressible solids crush when they are exposed to ultrasound. Hence, exposing crystals with ultrasound waves during freezing process leads to their fragmentation and consequently, their size reduces. By the propagation of ultrasound waves in compressible solids, the materials compress and expand alternatively (like pressing and releasing a piece of sponge). This phenomenon is called sponge effect (Chemat et al., 2011).

Waves with low intensity: the studies indicated that these waves are non-destructive (Christopher et al., 1997). Their applications include food quality control (non-destructive measurement of properties), process control such as controlling fluid flow and detection of foreign bodies, etc (Cho & Irudayaraj, 2003). Presence or absence of material between a pair of transducers or between one transducer and a Refract meter can be determined by measuring the amplitude of the electrical wave. If there is a material, the amplitude of the electrical wave will reduce (Nyborg, 2001).

1.2. Ultrasonic as a Method of Food Preservation

Food preservation can be defined as a method of increasing the preservation time of raw materials and processed food for a longer period of time than the normal time of corruption (without human interference). This method is considered as a competition between various physical, chemical and biochemical processes. Moreover, increasing the preservation time depends on the development of various microbial populations that can be often helpful but are mostly harmful for the preservation of foods desired properties (Mason et al.,).

2.2 The Application of Ultrasonic Waves for Dairy Materials

Using Ultrasonic waves with high intensity in dairy industry led to the inactivation of bacteria and enzymes, homogenization of milk, cheese products increase, purification, etc. Low-intensity waves were used to determine the composition of milk and dairy products, that is, fat cells concentration, fat-free solids and the whole solid.

Velocity and attenuation of ultrasonic waves in the dairy products depends on their microscopic structure and composition. Ultrasonic attenuation measurement is a useful method in determining milk coagulation time and the physical viscosity variations during the coagulation of milk non-destructively. When milk is coagulated, the attenuation coefficient is greatly reduced. Ultrasound waves are used to evaluate the process of cheese ripping, structure wastes and the formation of hollow cavities in cheese because cheese properties influence the determination of ultrasound velocity and attenuation. In addition, this method is utilized for estimating the size and concentration of bubble in whipped cream and yogurt.

Ultrasound effect in enhancing lactose hydrolysis in fermented milk is evaluated by Lactobacillus Delbrucki as a subtype of Bacillus Bulgaricus. Fermented milk contained a small amount of Lactose for lactose-intolerant individuals (Chyung, 1994).

Raw and treated pasteurized milk with ultrasound have the same or lower favor and taste than unprocessed heated milk. However, if heated milk is exposed to ultrasound for two minutes would have a better taste on the fourth day of preservation compared to untreated milk (Chouliara et al., 2010).

2.3 Basis of Ultrasonic Waves Function

In sound and supersonic sound waves, severe shaking with or without adding small neural particles (such as small glass balls or small shots) may cause significant damages or kill spores and growing shapes of bacteria (gram-negative bacilli). The effecting mechanism of these waves is the temporary formation of gas cavities within the body of bacteria and the formation of mono-oxygen and the Hydrogen peroxide and DNA fragmentation.

2.4 Synthetic of Inactivating Dairy Micro-organisms

Generally, in food industry the focus is on inactivating enzymes or destroying micro-organisms. Using heat plays an important role in food preservation but it can damage food. For examples, the loss of nutrients and the reduction of sensory properties can be presented. Therefore, the scientific communities seek to find alternative methods for food preservation based on different physical principles. Attempts to use the ultrasound waves for food preservation is not new, but in the past 10 years great progresses has occurred and it has been partially regenerated. The first studies regarding ultrasound applications in food industry were allocated to the most important factor in food, whichis a microbial population (Mason et al., 2003).

Micromechanical electric shocks are generated by making and breaking the induced microscopic bubbles with pressure fluctuations caused and can disable micro-organisms. Micro-organisms inactivation is more effective when the ultrasound system is applied with other methods such as the combination of pressure, heat and the ultrasonic which is called the process of "mono thermo sonication" (MTS). In this case, this process (MTS) showed a fatal effect on thermal resistance of some bacteria and enzymes.

In combination of ultrasound and heat, first the waves are used before heating (in order to make micro-organisms sensitive to the following heating process).

Scientists in Spain, firstly, evaluated the ultrasonic waves 'behavior by heating various types of products and their behavior without heating and only in pasteurization temperatures. The results of the experiment showed that the fatal effects on Bacillus Subtilize increased. This was in fact due to a drop in bacteria resistance (Sala et al.,).

Ultrasound waves create shrinkage in the size of particles through the phenomenon of cavitations. In heterogeneous systems such as milk, the effect of ultrasound is attributed to regular or irregular cavitations. Severe dissipation of cavitations bubbles generated strong local heat and high pressure. The tension and frequent bursts of bubbles damaged the wall of materials. These severe damages imposed spatial and temporary tension on the surface of materials and eventually, they lead to the fragmentation of the particles (Piyasena et al., 2003). Using ultrasound waves with maximum energy level for long period with the repetition of wave flow generated small-sized fat globules. The first application of homogenization was proposed by Chambers (1937). He stated that this method is effective for decreasing fat globules (Chambers, 1937). Schimdt (1985) examined the homogenization of ultrasound waves on milk at 60C°. The results of his study indicated that the size of fat globules was less than 1mm. Ertugay and Sungel (2004) studied the effect of homogenization with ultrasonic waves of 20 KHz and compared their findings with normal homogenizers. The size of fat globules after normal homogenizer was 2-5 μm. They concluded that ultrasound compared to normal homogenizers reached better results in milk homogenization and the impact enhances as the time increases (Ertugay & Sungel, 2004).

2.5 Homogenization Using Ultrasonic

Oneof the main objectives of ultrasonic waves is for milk homogenization. The reason for the application of these waves is the fragmentation of fat globules into smaller sizes. In this way, the consumed energy decreased and the dissipation energy dropped as well. Ultrasonic waves cannot directly create stimulation and the vibration of fat globules. However, it may cause cavitations and severe osteoporosis and as a result lead to liquid bubbles breaking.

2.6 Fermentation products

Today, all over the world the consumption of fermented dairy products has increased because they are delicious and nutritional. Therefore, for the production of these products new methods need to be applied to improve the quality, taste and packaging. Homogenization is a crucial pre-treatment for the preparation of milk, yogurt and ice-cream because this can prevent clotting during incubation period and storage. Toba (1990) reported that ultrasound improved lacto Bacillus functions about 50% and it also included the effect of desalination of yogurt without increasing the caloric amount.

2.6.1 The Effect of Ultrasound on Fermentation Products

1. PH variations: when ultrasonic energy is used for 8 minutes, no reactivating in dairy bacterium would occur and to some extent it stimulates acid evolution. The majority of lactic acids are produced; therefore, the fermentation time is reduced to half an hours.
2. Water preservation capacity: ultrasound increase water preservation capacity considerably.
3. Viscosity: ultrasound can make dramatic changes to the dairy concentration and enhance the concentration of drying products.
4. Synersis: the effect liquid analysis resulted from sour dairies which are regarded as an unpleasant or harmful characteristic. Therefore, due to variations in water preservation of milk patients homogenization is performed and it leads to a drop in synersis (Williams).

2.7 The Application of Ultrasonic in Some Food

1. Edible oils and fats
2. Meat and fish
3. Using ultrasound waves in abattoirs (Schutt, 1992)
4. Dispatching insects (Schutt, 1992)

2.8 General Applications of Ultrasound in Food Industry

Thickness measurements, surface and temperature in addition to determining fruit, vegetables, meat, and dairy and other products' components are of the most common applications of ultrasound waves in food industry. Ultrasound was used to measure the components of most of the foods including the amount of fat in oily foods, milk components, sugar concentration, the amount of alcohol in alcoholic beverages, air measurement in bulky food, salt concentration in brine, bio-polymers concentration in gels and aqueous solution (Soria & Villamiel, 2010). Additionally, using ultrasonic facilitates data collections where other methods are difficult to be applied. For example, continuous and automatic monitoring and inspection of the production lines such as the determination of particles size produced by Homogenizers, colloid grinding and mixer. Moreover, clarifying the amount of fouling pipes, thickness of sweet or chocolate and the thickness of fatty or fat-free tissues of meat and measuring the available liquids in tasks and determining the temperature are possible when conventional sensors are not possible to be utilized (Aamio et al., 2005).

3. RESULTS

Ultrasound is a useful tool to study various physical and chemical foods. Using ultrasound as "online sensor"can provide a strong tool in processing and quality control of the products and lead to quality improvements and lowering costs of production. Expansion of ultrasound applications in food industry depends on the availability of specific ultrasonic devices and the presence of individuals who are aware and familiar with measuring and interpreting ultrasonic data. Currently, the application of it in food industry is associated to the optimization of chemical reactions in degassing from solution and beverages, surface, food, equipment cleaning, sterilization of objects or fluid, extracting food consistent components, emulsification, homogenization, modification of enzymatic activities, depolymerization of polymers, foams removal, melting, drying, cutting, releasing food from molds, meat embrittling, filtration recovery, accelerating ripening, bacteria isolation from nutrients and foods and their concentration.

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