INTERNATIONAL RESEARCH JOURNAL OF PHARMACY
www.irjponline.com ISSN 2230 – 8407
Review Article

UTILIZATION OF ULTRASOUND TECHNOGICAL ADVANCES IN FOOD INDUSTRY

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Article Received on: 11/01/12 Revised on: 15/02/12 Approved for publication: 19/03/12

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ABSTARCT
Ultrasound has been employed for processing purposes in industries and now it is emerging as a perspective technology in different segments of food industries. This potential technology is gaining rapid momentum in food processing organization. Earlier, ultrasonics was used for cleaning purposes in food sectors. The range extends from the cleaning of nozzles used in breweries to the cleaning of bread pans in bakeries. Besides cleaning, it has also proved its significance and potential for the extraction of juice, concentration of thixotropic composition, homogenization and emulsification, improving crystallization rate and drying. This broad spectrum of application can safeguard its use as a valuable technology of the 21st century.
Keywords: Piezoelectric effect; Magnetostriction effect; Microorganisms; Fobbing; H_2O_2; Homogenization; Emulsification; Safety problems

INTRODUCTION

Ultrasonics as a technology can probably be said to have valuable position from its birth during World War I in a laboratory in Toulon (France) when Prof. P Langevin designed and built a high power ultrasonic generator which used quartz crystals as active elements. Today, the number of ultrasonic processing devices in commercial use is in lacs. The two main mode of ultrasonic production are the piezoelectric effect, we can produce ultrasonic frequency around 540KHz by quartz crystal and around 1.5MHz by tourmaline crystal. By using Magnetostriction effect, we can produce ultrasonic waves of frequency 8-20 from few hundreds to 300 KHz changing dimensions and mode of vibrations. The application of ultrasound within food industry has been a subject of research and development for many years. Many laboratory studies of the potential applications of this energy have been performed; however, little of this work has been reported in depth. The sound wave in which, the frequency is above the limit of human audibility i.e. greater than 20KHz referred to as an ultrasonic wave. The upper frequency limit is indefinite since it is continuously increasing as new techniques are discovered. It is now 10 GHz in laboratory applications. The reason why frequencies above, rather than below, the audible range are used is that the people who have to be in the vicinity of the equipment are more comfortable because there is less noise. Another reason is that many processing applications require high acceleration and it is easier to get this high acceleration by high frequencies. Ultrasonic vibrations can be produced in any sort of materials-gaseous, liquid or solid. It is important to realize that the passage of sound wave through some materials does not produce any net displacement of the material around their equilibrium position[1,2].

Application Of Ultrasound In Food Industry

In 1920, it was reported that the bacterial effect in foods can be reduced using ultrasound. As a general rule, small microorganisms are less easily damaged than larger one. At low intensity, the tendency is for growth to be stimulated because individual member of a colony is dispersed. If ultrasonic power is increased at a certain threshold; destruction of microorganisms sets in and with further increase, the rate of destruction increases. The bactericidal effect is reduced due to mechanical disruption of cells by very intense currents generated within the media by ultrasound. The main lethal effect is due to cavitation. Highly reactive chemical radicals and reaction product e.g. H_2O_2 of well known lethal capacity are librated in the aqueous media during cavitations. Also there is extreme pressure variation caused by implosion which generates very high temperature. It has been observed that microorganisms can withstand high pressures but they are incapable of withstanding the quick altering pressures produced during cavitation. Presently, some problems are still to be cleared and explored but it is definitely and reasonable to presume that ultrasound could be applied to the pasteurization or sterilization of fruit juices, milk or other liquid products within the next twenty years. Other applications may also include its minor use in 'fobbing' of carbonated beverages, particularly, beer. In the production of bottled beer, it is important to remove all air from the bottle above the beer surface. If this is not done, then some bacteria present in air can produce certain reactions that will give taste to the beer. The use of ultrasound in the plastic packaging of foods where plastic welding is necessary for sealing has been reported[1]. Ultrasonic plastic welding of containers is excellent for heat sensitive foods, since the heat for welding occurs only into the food being packaged. The applications of ultrasound in food industries are summarized as follows[3-5].

Concentration Of Thixotropic Composition

Recently[6] a process has been developed to preserve the citrus fruit juice. Using high frequency vibrations, the likelihood of impairment of flavour is minimized. This process is carried with continuous recycling of the product withdrawn from the evaporator back through the ultrasonic treatment unit into the evaporator. In this manner the concentration is increased gradually up to the desired level. Fruit juice of a concentration of 75º to 85º Brix can be prepared. The preparation of juices of purees of such a high level of concentration is very desirable since at this level of concentration no special measure for preservation such as

pasteurization or freezing have to be taken. All that is required with such a product is stored under refrigeration so as to prevent non-enzymatic browning. Such a degree of concentration could not be achieved even with modern evaporators containing heat exchangers designed to cause high turbulence of the concentrate. The highly concentrated juices obtained by this process are considerable less viscous than would be the case if concentration of the same degree were prepared.

Homogenization And Emulsification

A treatment of a two-phase liquid system by ultrasonic cavitation can be readily accomplished either on a continuous basis in a tank. The mechanism that is effective in homogenization and dispersion is the extremely high instantaneous localized pressure pulse that results from the cavitation process. They propel minute droplets are very small hence they are more apt to be stable. In a system consisting of two immiscible liquids if cavitations occur at the interface between the liquids, one phase become dispersed in the other. The emulsions are often more stable than those produced conventionally and generally require little, if any, surfactant. The applications for ultrasonic homogenizers in the food industry include the manufacture of salad creams, ice-cream mixes, cream soups, essential oil emulsions, covertures chocolate, artificial creams, baby foods, beverage emulsions, beverage flavours, chocolate syrup, chocolate drinks, condensed milk, ice cream, etc.

Concentartion By Crystallization

Ultrasound ranging from 20KHz to 100 KHz is extremely useful in crystallization processes. It serves a number of roles in initiation of seeding and subsequent crystal formation and growth. New researchers[5-7] have reported a method for concentrating an aqueous solution is contacted with carbon dioxide (CO_2) to form a slurry of ice crystals in mother liquid and the slurry is passed to a crystal growth zone. The process using beer as the representative aqueous solution can be cited as an example.

Extraction Of Juice

The mechanical effect of ultrasound provides two major benefits which increases the extraction rates:

(i) Improved mass transfer to and from interfaces

(ii) The disruption of biological cell walls on the surface and within the plant material to facilitate the release of contents

A mechanical orbital mass type of sound wave generator is used which produces sonic waves of relatively low frequencies as compared with the audible spectrum typically from hundred Hz to an order of 20KHz. The process is mainly used for fruits and vegetables. The vegetable or sugarcane is first chopped up into fairly small pieces. The chopped material is then placed in a treatment chamber and covered with a small quantity of liquid such as water to serve as an acoustic coupling medium within the treatment chamber, the one wall is sound wave radiating surface. The sound wave is transmitted viz. liquid to and through the pieces of vegetable substances or sugarcane. The sonic wave energy has an action on the vegetable substance, which results in a differential vibration of the fibre and juice. Due to differences in densities, elasticity and fractional resistance, the acoustic impedance of fibres and juice is different in magnitude and phase angle. Thus fibres and juice substances must vibrate at different amplitude and in different time phase in response to transmission of sonic waves. Also, sound wave transmission results in the juice and fibres ingredients vibrating with different accelerations and to different maximum velocities. Further, the velocity of sound in fibres differs from that in the juice[8].

Drying

Acoustic drying is potentially great commercial importance. Sonically enhanced drying can be carried out at lower temperatures than by conventional methods, which reduces the probability of oxidation or degradation in the material. The high particle velocity that exists in a sound wave can be used to promote drying of various materials in powder, sheet and fibre form. This also an extraction process and involves the change of moisture concentration gradient near the surface of the material being dried. The gradient is modified by the vigorous agitation of the air by sound wave. This method of drying has an advantage in the case of heat sensitive material and where high velocity steady air current might blow away or damage the product. Another reason is that it can penetrate around and behind particle and reshape by echoing.

Cleaning

An application of ultrasonics outstandingly successful is in cleaning processes. This has been proved to be more efficient technology than any other conventional method. Ultrasound is particularly useful in surface decontamination where in the rush of fluid, which accompanies the collapse of cavities near a surface. With proper solvent, wetting agent and proper temperature, the efficiency can be increased. The task is simpler if the contaminant is brittle. Viscous insoluble films that wet the surface are somewhat difficult to remove. Root vegetables can be ultrasonically cleaned although the continuous removal of dirt from the cleaning solution and pre-washing is usually desirable. Dirt trapped in holes or crevices is rapidly removed. It also extends from the cleaning of nozzles used in breweries to the cleaning of bread pans in bakeries. It is perhaps interesting to note that ultrasonic cleaning used in bakery is the only effective technique. Any spongy bread or cakes tends to absorb sound and prevents cavitations, therefore, the soft material must be removed first by soaking and brushing[4].

Safety Measures

The effect of ultrasound on the operator is a major concern. The ill effects that may result from the operation of ultrasonic equipment might be hearing loss and other physiological effects such as: fatigue, nausea and pain, etc., due to air borne noise radiated by equipments and the local damage resulting from direct contact with an ultrasonically vibrating device. The following safeguard can be taken against unnecessary exposure to air borne noise from ultrasonic equipment while locating the equipment in an area where personnel who are not working with the equipment do not construct an enclosure around the equipment leaving one side open, if necessary, compel workers who are in high noise region; to wear devices to keep an excessive amount of sound away from reaching their ear and making no contact of any part of the body with any ultrasonically vibrating device. Though, there has been no proven medical evidence that industrial ultrasound has had any effect on the operators of equipment and use of ultrasound in food industry has not proved to be dangerous in any way[9,-11].

CONCLUSION

The growth of ultrasonics is following a natural pattern for any fledging field. Initially, ultrasonics was found to be extremely efficient for the production of an oil and water emulsion. Its applications have broadened considerably and now it is believed that ultrasonics is set to make a considerable impact on the food industry over next decade.

Several factors viz. new materials which can reduce the cost of ultrasonic equipment, methods for producing vibrations of sufficient intensity and consequently, more powerful sources of vibrations, improvement in basic designing and finally the availability of trained personnel, have to be explored in depth to make the application of ultrasonic more meaningful and significant in food industries.

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