

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ОДЕСЬКИЙ НАЦІОНАЛЬНИЙ ТЕХНОЛОГІЧНИЙ
УНІВЕРСИТЕТ



ЗБІРНИК
НАУКОВИХ ПРАЦЬ
МОЛОДИХ УЧЕНИХ,
АСПІРАНТІВ ТА СТУДЕНТІВ

Одеса 2023

Наукове видання

Збірник наукових праць молодих учених, аспірантів та студентів

Матеріали, занесені до збірника, друкуються за авторськими оригіналами.
За достовірність інформації відповідає автор публікації.

Рекомендовано до друку та розповсюдження в мережі Internet Вченою радою
Одеського національного технологічного університету,
протокол № 14 від 20.06.2023 р.

Під загальною редакцією Заслуженого діяча науки і техніки України,
Лауреата Державної премії України в галузі науки і техніки,
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Збірник наукових праць молодих учених, аспірантів та студентів.

Міністерство освіти і науки України. – Одеса: 2023. – 395 с.

APPLICATIONS OF ULTRASONIC ENERGY IN THE FOOD INDUSTRY

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The goal of thermal technologies is to reduce processing time, save energy and increase the shelf life and quality of food products. Thermal technologies (radio frequency and microwave heating), vacuum cooling technology, high pressure processing and pulsed electric field technology are new technologies that have the potential to produce high quality and safe food products, but are limited by high investment costs, lack of approval regulatory bodies and, importantly, consumer acceptance are delaying the wider industrial adoption of these technologies.

In recent years, ultrasound (US) in the food industry has become a subject of research and development. The great interest in ultrasound is due to the fact that the industry can be provided with practical and reliable ultrasonic equipment. Now, its emergence as a green new technology has also drawn attention to its role in environmental sustainability.

The main advantage of using ultrasonic energy in the food industry is the acceleration of many technological operations.

The benefits of using ultrasound for food processing include more efficient mixing and micro-stirring, faster energy and mass transfer, reduced temperature and concentration gradients, fewer equipment, increased productivity, and the elimination of certain processing steps.

It has been established that ultrasound can affect the texture of meat. There is evidence that US causes damage to the perimysal connective tissue, resulting in improved meat texture. Also, sterilizing meat with heat and ultrasound leads to tissue softening.

Marinating is used for a wide variety of vegetables and meat products. Most modern salting or salting-fermentation processes have three main disadvantages: salting requires a very high sodium chloride content, which may require a "desalting" process before being sold; there is a potential lack of control over fermentation due to the occurrence of a natural external invasion of "wild" fermentation; and the brine curing process can lead to enzymatic texture change and structural damage.

All three of these side effects are detrimental to the rapid and efficient preservation of food, so alternative technologies are of interest to food manufacturers. Ultrasound can significantly reduce the time of marinating products. It also provides a method for producing a low sodium chloride marinade compared to the marinade currently on the market. In addition, ultrasound reduces the salting time, and also ensures the uniformity of salting.

Conventional thermal pasteurization and sterilization are the most common methods currently used to inactivate microorganisms and enzymes in foods. Unfortunately, the intensity of processing, time and temperature of the process are also proportional to the amount of loss of nutrients, the development of undesirable flavors and the deterioration of the functional properties of food products. Ultrasound provides a method for improving such processes through the effects of cavitation. The use of ultrasound in pasteurization continues to be of great interest to the dairy industry. It has proven effective in killing *E. coli*, *Pseudomonas fluorescens*, and *Listeria monocytogenes* without adversely affecting the total protein or casein content of pasteurized milk. The mechanism of microbial destruction is mainly associated with the thinning of cell membranes, local heating and the formation of free radicals. Studies on the effectiveness of ultrasound have also shown the inactivation of enzymes such as pectin methylesterase, polyphenol oxidases and peroxidases responsible for spoiling fruit and vegetable juices, as well as various enzymes affecting milk quality.

Combined with heat, ultrasound can speed up the rate of food sterilization, thereby reducing the duration and intensity of the heat treatment, as well as the associated damage. The advantages of ultrasonic pasteurization compared to heat pasteurization include minimizing flavor loss, greater processing uniformity, and significant energy savings.

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CAVITATION IN THE FOOD INDUSTRY

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Cavitation is used in various fields of science and industry. This phenomenon is used in the medicine, metallurgy, chemical, oil and gas industries. Due to its properties, it is widely used in the food industry. The availability, efficiency and simplicity of the equipment has made it possible to extend the use of cavitation to many food production processes. Such operations are: emulsification, separation, extraction, salting and pickling, pasteurization and sterilization, etc. A deeper study of the cavitation mechanism will allow finding new ways to apply this effect.

Cavitation is defined as the combined phenomenon of formation, growth and subsequent collapse of microbubbles or cavities, which occurs in an extremely short time interval (milliseconds) with the release of large amounts of energy at the transformation site. Very high energy densities (energy released per unit volume) occur locally, resulting in high pressures (in the range 100 to 5,000 bar) and temperatures (in the range 1,000 to 10,000 K). Cavitation also results in the formation of highly reactive free radicals, an increase in the surface area of solid catalysts, and an increase in the mass transfer rate due to turbulence resulting from fluid circulation.

Cavitation is generally classified into four types based on the method of generation, namely acoustic, hydrodynamic, optical or corpuscular cavitation. Among them, acoustic cavitation (AC) and hydrodynamic cavitation (HC) are commonly used in the food industry due to the ease of operation and the ability to achieve the desired properties of the food product. Acoustic cavitation, usually generated by ultrasound, is used effectively in the food industry for various chemical (eg, polymerization, sterilization, etc.) and physical (eg, emulsification, cell disruption, homogenization, etc.) processes. etc.

Hydrodynamic cavitation has been used successfully in a variety of applications including microbial cell destruction, wastewater treatment, biomass pretreatment, and biodiesel production. HC improves drying efficiency during scaleless heating, spray drying and emulsification. Other HC applications include microbial sterilization, radical and intracellular enzyme release.

An example of the use of acoustic cavitation is to improve the extraction of biologically active substances from plant materials. Vibrations caused by acoustic cavitation can help break down cell walls and release biologically active substances, which can increase their recovery from plant materials. This can be especially useful in the production of functional products such as beverages, dietary supplements, etc. The rate of extraction is increased despite the temperature is not raised high. Short process time and low temperature ensure a high degree of indestructibility of biologically active substances.

Acoustic cavitation can also be used to process liquid products such as milk, juice, beer, etc. It improves the quality of the product, extends its shelf life and improves the flavor and texture.

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