Irradiation

Food irradiation is the process of exposing energy in the form of rays for improving food safety, eliminating and reducing organisms that destroy the food products. Electromagnetic radiation (X-rays and gamma rays) and electron-beam radiation are forms of ionizing radiations applied on food among the various ionizing radiations.

Application of ionizing radiation treatment of foods on an industrial scale started in the early 1980s after the joint Food and Agriculture Organization/International Atomic Energy Agency (IAEA)/World Health Organization (WHO) expert committee accepted the application of a 10-kGy overall average dose for foods.

Irradiation is used as a food preservation method to destroy microorganisms and increase shelf life. The **radiatio**n dose unit, previously referred to as the rad, is currently known as the **Gray** (Gy). The Gy is the absorption of 1 J of energy per kilogram irradiated material and is equivalent to 100 rads.

Radiation equipment is composed of one high energy radiation source (isotope source) to produce gamma rays, or less frequently, by an equipment which emits high electron-beam energy.

The frequency of the gamma rays is above 1019 Hz, which implies in wavelengths below 10–12 m. Gamma radiation is produced from the excited nucleus of radioactive elements, such as Cobalt 60 (^{60}Co) and Cesium 137 (^{137}Cs).

The process of irradiation by gamma rays has several advantages: low heat generation, low energy requirements, irradiation of packaged or frozen products, and cause changes in the food nutritional value similar or inferior to other methods of conservation

This is a very mild treatment, because a radiation dose of 1 kGy represents the absorption of just enough energy to increase the temperature of the product by 0.36°C.

It means that, heating, drying and cooking cause higher nutritional losses. Moreover, heterocyclic ring compounds and carcinogenic aromatic produced during thermal processing of food at high temperatures were not identified in irradiated foods

* Irradiation is required to kill microorganism present in food.

* Irradiation is used to preserve proteinous food such as meat, fish, fresh fruits, vegetables, flour, spices etc.

* Irradiation does not denaturate protein does not alter taste and does not leave any radioactive residue in the food.

* Loss of vitamins is less as compared to canning, freezing or drying.

One of the causes of organoleptic changes in milk, lipid peroxidation, has been monitored by a sensitive assay newly applied to foodstuffs. It has been shown that even at medium radiation doses (up to 3600 Gy) negligible lipid peroxidation takes place, providing the milk is thoroughly gassed with nitrogen.

The data indicate that, although the deleterious lipid peroxidation effects of irradiation can be minimised by the removal of air, this in turn results in a degree of protection being afforded to the bacteria, and that doses in excess of 1600 Gy are needed to effectively sterilise milk.

Cheeses are also included in ready-to-eat foods. The pathogenic and toxin-producing microorganisms (considered in studies on irradiation of cheeses) are L. monocytogenes, pathogenic E. coli, Salmonella, Clostridium, Staphylococcus (mycotoxins), Brucella and Mycobacterium.

When dairy products are treated with ionizing radiation, the first effect is the possibility of radiation penetration to all areas of the product, especially lactic starters in large containers and thus ensure the disposal of microbes and to ensure full sterilization of the product.

The use of irradiation technology for milk and milk products is limited. There are two reasons that hindered the widespread uses of ionizing radiation in the preservation of dairy products: first reason is due to the composition of dairy products in terms of high moisture and fat content ; the second reason is the consumer acceptance of irradiated dairy products.

The second effect of radiation in dairy products is attributable to the impact of some characteristics of the quality of milk and milk products such as prescription of color and flavor.

Irradiation processing has been successfully used to reduce pathogenic bacteria, eliminate parasites, decrease postharvest sprouting, and extend shelf life of fresh perishable food. It has a potential for use in preservation and extending the shelf life of certain milk and milk products.

Sonication

Ultrasonic processing is an evolving technology in food processing. These ultrasound-induced physical effects are finding increasing use in food and dairy processing, in applications such as the enhancement of whey ultrafiltration, extraction of functional foods, reduction of product viscosity, homogenization of milk fat globules, crystallization of ice and lactose and the cutting of cheese blocks.

When ultrasound wave passes through a liquid, bubble nuclei present in the liquid grow by bubble coalescence and rectified diffusion. When these bubbles reach a critical size range, they collapse under near-adiabatic conditions generating extreme conditions within the bubbles and in the surrounding liquid that include intense shear forces, turbulence and micro streaming effects

Ultrasound refers to sound waves above the frequency of human hearing ($\sim > 18$ kHz). When high-intensity ultrasound is passed through a medium, strong vibration of the medium occurs. Such mechanical vibration effects can be used in cleaning and extraction applications. In addition to the mechanical vibration effect, ultrasound also generates acoustic streaming within liquids

Ultrasound technology utilizes mechanical waves at a frequency above human hearing threshold (>16 kHz). These waves can be categorized into two frequency ranges (1) low-energy (high frequency, low power) utilizing frequencies higher than 100 kHz at intensities below 1 W cm−2 and (2) high-energy (low frequency, high power) utilizing frequencies between 20 and 500 kHz and intensities higher than 1 W cm−2

In the food industry, the application of ultrasonication has gained popularity in various fields, such as nondestructive testing, extraction, homogenization, degassing, antifouling, cutting of frozen or soft food, microbial destruction, etc. Recently, researchers have shown great deal of interest in harnessing the potential of ultrasound in the field dairy industry.

Various researchers have demonstrated the potential of ultrasound application in modifying milk components, improving efficiency of milk and milk product processing, food safety and microbial destruction, nondestructive analysis, equipment surface cleaning, and waste management. Similarly, potential of application of HC in dairy industry has been studied by many researchers.

Some of this knowledge has been successfully applied in dairy industry such as ultrasound-assisted sealing of UHT packaging to improve yoghurt. However, still a great deal of further research is required to extend application of these techniques at industrial level. Most of the ultrasonication researches were focused on dairy products such as milk, cream, cheese, yoghurt, and milk protein-based ingredients; however, to our knowledge, no study is done on other milk products such as anhydrous milk fat and butter. It would be interesting to see what ultrasonication and HC can do to these products as well.

Applications of ultrasound and cavitation are well established in other industry, the ultrasonic processing of dairy ingredients and products are gaining much attention recently and it has a great potential to become a mainstream process in dairy industry in the near future.

Use of ultrasound as an alternative method of processing dairy products has been explored in recent years and examined in terms of physical and functional properties of the food product.Emulsification of milk products is of interest and several studies have examined the effect of ultrasound on the degree of emulsification and the overall homogenisation of the final drink.

Sonication has also been employed to disrupt casein micelles and produce milk containing smaller particle sizes. This milk has shown enhanced renneting ability with the potential of more efficient production. Sonication of fresh cow milk resulted in a reduction in the size of fat globules. Homogenization at a power level of 40 for 10 min was similar to conventional homogenization.

Mano-thermo-sonication

Manothermosonication (MTS) combines the ultrasound with moderate temperature and pressure in order to inactivate enzymes and/or micro-organisms. Manothermosonication consists of the simultaneous application of heat and ultrasound under moderate pressure (100-700kPa).

The application of ultrasound to conventional dairy processes has the potential to provide significant benefits to dairy industry such as possible cost savings and improved product properties. This technique has seen convincing developments for food preservation owing to its ability to inactivate microorganisms and endogenous enzymes while retaining nutrients and flavor.

Manothermosonication is an efficient tool to inactivate enzymes and bacteria in milk. MTS in dairy industry is established that MTS treatment by virtue of its mechanism is best suited for acidic pH products.

During the past decade, the technology has rapidly emerged as a mild non thermal processing tool capable of replacing or assisting many conventional dairy processing applications such as inactivation of microbes and enzymes, homogenization and emulsification, creaming, crystallization, and functionality modifications within dairy systems. Moreover, ultrasonic is an as a safe processing technique compared to other emerging technologies

A few researchers have examined the possible uses of this technology in dairy products. Dolatowski et al.,) reported that the use of ultrasound as a processing aid can reduce the production time of yoghurt of up to 40 per cent.