FACULTY OF ENGINEERING & TECHNOLOGY

DEPARMENT OF BIOTECHNOLOGY

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1. Ionizing radiations

Ionizing radiations are of primary interest in food preservation. These radiations have wavelengths of 2000 Å or less; for example: α particles, β rays, gamma rays, X-rays, and cosmic rays, their quanta contain enough energy to ionize molecules in their paths. Ionizing radiation is applied to foods to improve their keeping quality (Figure 1). Foods processed with ionizing radiation are known as "irradiated". They are not "radioactive" and such radiations destroy microorganisms without appreciably raising temperature hence; the process is called cold sterilization.

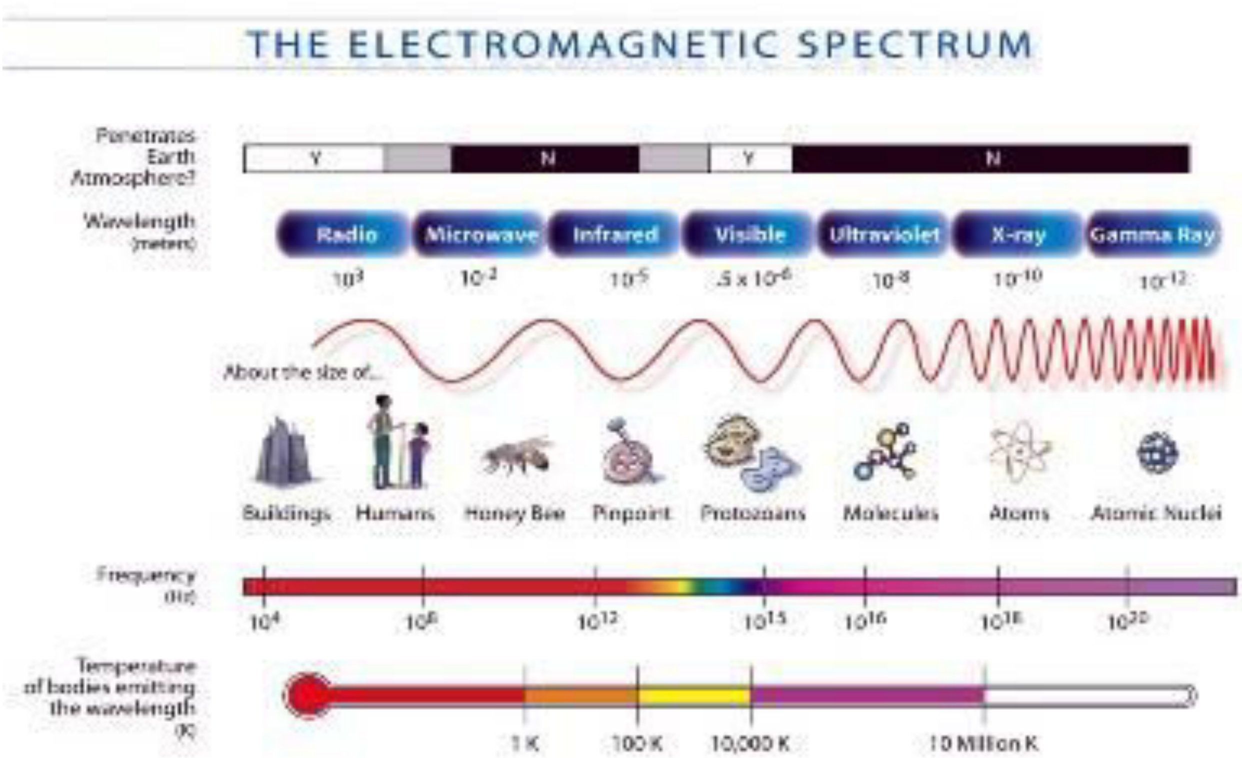

Figure 1: The Electromagnetic Spectrum

The microbial cells are affected directly and indirectly by ionizing radiations:

a) Direct effect:

Because these radiations interacting with key molecules (chromosomes: where OH radicals cause single and double strand breaks in the DNA molecule, resulted removal of hydrogen from deoxyribose sugar) within the cell.

a) Indirect effect:

Generation of free radicals by the radiolysis of water and further free radicals can combine with oxygen molecules to give powerful oxidizing agents that can damage cell components. Therefore, food without water and oxygen requires higher radiation doses (2-3 times) required to obtain the same lethality of food with sufficient water and oxygen.

1.1 Gamma Rays

Gamma rays playing very important role in food preservation because it is the cheapest form of radiation and the source elements are either by- products of atomic fission or atomic waste products. Gamma rays have excellent penetration power similar to UV light, making it potentially an ideal method of food preservation. Hence, gamma rays can be used to kill or destroy contaminating microorganisms packaged food. Such type of electromagnetic radiations emitted from the excited nucleus of elements i.e. 60Co and 137Cs. In addition to above, 60Co has a half-life of about 5 years and the half-life for 137Cs is about 30 years.

2. Non-ionizing radiation

In search for new and better food preservation methods, the research has turned to the possibility of using radiations in different ranges of frequencies, such as nonionizing radiations. This type of radiation does not have sufficient energy to break molecular bonds or remove electrons from atoms; in other words, perform ionization. The types of frequencies characterized as nonionizing are ultraviolet, infrared, radiofrequency, laser, microwave, and visible light [9, 10]. However, the use of nonionizing radiation has low interest as a food preservation method, in contrast to ionizing radiations

2.1 UV Radiation

Ultraviolet (UV) light is considered powerful bactericidal agent and with the most effective wavelength being about 260 nm. It is non-ionizing type of radiation. Microbial proteins and nucleic acids showed maximum absorbance. In general, UV light is absorbed by purine and a pyrimidine base leads the formation of covalent bonds between adjacent thymine molecules, resulted thymine dimers. These may interfere the process of DNA replication as well as disrupt normal gene functioning, which creating new mutants. Naturally, microorganisms have the capacity to repair this DNA damage but extensive damage may cross the limits of DNA repair mechanisms leading to cell death. Microbial resistance to UV light is largely determined by their ability to repair such type of damages. Beside these repair mechanisms, few microbes also synthesize some protective pigments (Micrococcus luteus produces yellow water-insoluble pigments).

In general, the sensitivity to UV irradiation follows the pattern: Gram-negative > Gram-positive > yeast > bacterial spores > mold spores > viruses. Ultraviolet radiation of high intensity can be generated by low-pressure mercury vapor lamps is considered extremely effective in killing microorganisms.

Figure 2: UV light on fresh food

Penetration capacity of any radiation playing very important role in food application, as UV light has the poor penetrating capacity, restricts its use. It can able to penetrate only to 3-5 meter in air, 0.3 meter in water and less than 0.001 meter glass and milk. Hence, the applications of UV light are limited to surface disinfections and air sterilization, surface sterilization of wrappers and packaging rooms in food and pharmaceutical industry.

2.2 Microwaves

In the electromagnetic spectrum, occupy frequencies between the infrared (10^9 Hz) and radio frequency (10^{12} Hz) and has comparatively low quantum energy. Microwaves are generated using a device first developed in the United Kingdom during research into radar during the Second World War called magnetron. For most food research mainly two frequencies; 915 MHz and 2450 MHz, are used. Microwave radiations act indirectly on microorganisms through the generation of heat In the microwave oven, when electrically neutral foods are placed in an electromagnetic field and the charged asymmetric molecules are driven first one way and then another. In this process, each asymmetric molecule attempts to align itself with the speedily changing alternating-current field and the molecules oscillate about their axes while attempting to go to the proper positive and negative poles, intermolecular friction is developed with apparent heating effect. This temperature effect is accountable for killing microorganisms in food. Microwave radiations are used both commercially and domestically in domestic microwave ovens and in catering to defrost frozen meats before cutting, in blanching of vegetables and fruits, destruction of molds in bread, pasteurization of beer and sterilization of wine etc.

2.3 Pulsed electric field

The pulsed electric field (PEF) technology, also known as high-intensity electric field pulses (HELP), refers to the application of high voltage pulses (20–80 kV cm−1) in a product situated between two electrodes (Figure 3). The inactivation of pathogenic and spoilage bacteria, yeasts, and some enzymes related to food quality have been demonstrated by several authors, although bacterial spore is not eliminated through this treatment. Regarding to this limitation, other methods are used in combination with irradiation technologies for the elimination of bacterial spores. The technology consists of subjecting the product to repeated high-intensity fields with short-time electrical pulses, (ms or μs), with the purpose of causing the inactivation of enzymes and destruction of microorganisms. The outline of pulsed electric field technology is shown in Figure 2. Regarding food quality attributes, PEF is considered superior to conventional heat treatment because it avoids or reduces changes in sensory and physicochemical properties. Many studies have reported the advantage of the application of PEF for the conservation of the micronutrient content of foods, once that is expect the thermolabile vitamins to be conserved, since the electric pulse method does not constitute a heat treatment. There are several factors that influence the results from the pulsed electric field on the microorganisms. These factors are related with the parameters of the process (time, field intensity, temperature, and number of pulses), to the characteristics of the product, and the characteristics of the microorganisms present in the product.

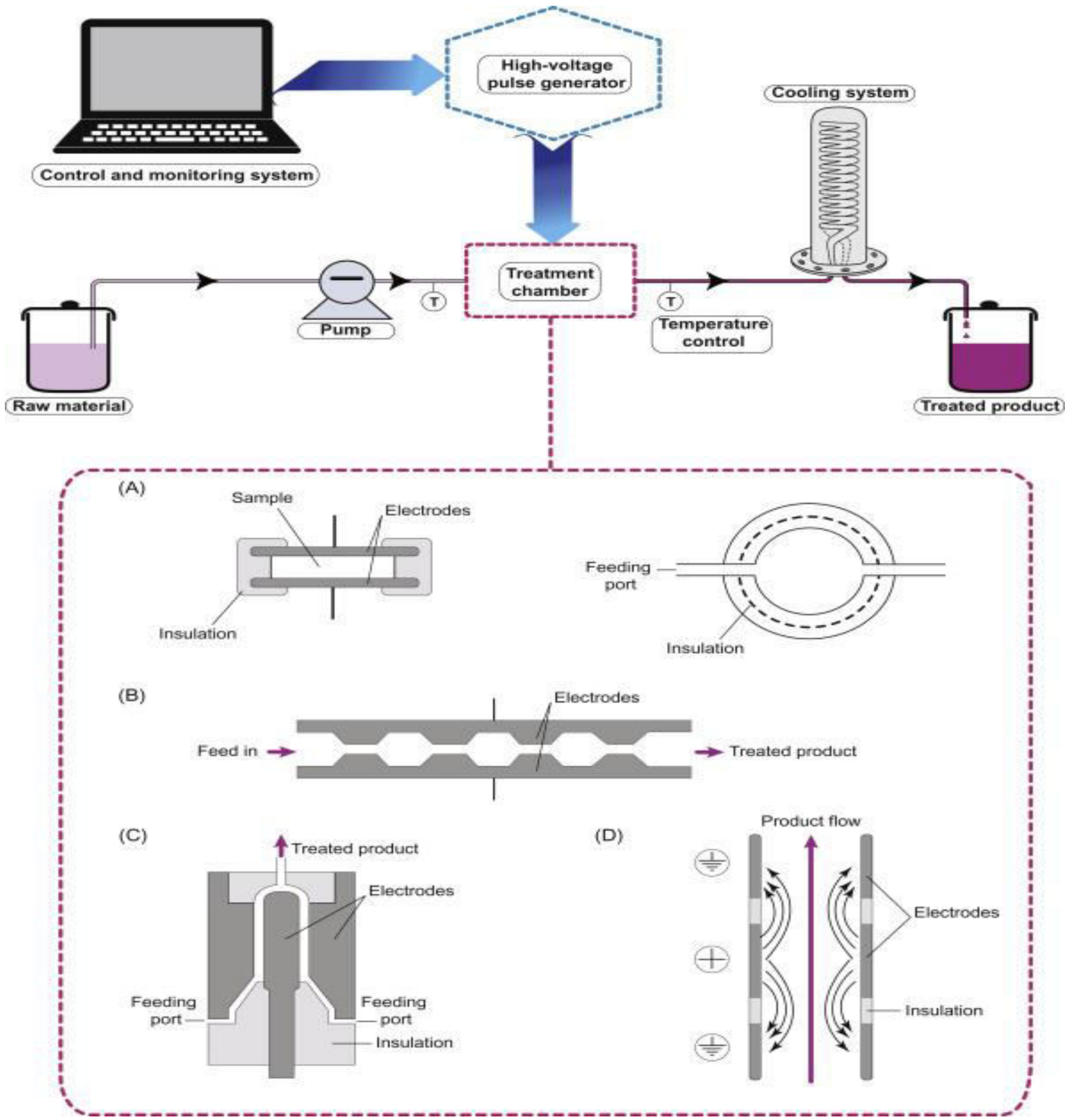

Figure 3: Pulse-Electric field processing of fruit juices