

Pulsed Electric Field Processing: Advanced Food Preservation Method

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Abstract

The application of any new technology presents significant challenges to food technologists and food researchers. Pulsed electric field (PEF) processing is a non-thermal method of food preservation that uses short bursts of electricity for microbial inactivation and causes minimal or no detrimental effect on food quality attributes. PEF processing involves treating foods placed between electrodes by high voltage pulses in the order of 20-80 kV/cm (usually for a couple of microseconds). The applied high voltage results in an electric field that causes microbial inactivation. PEF can be used for processing liquid and semi-liquid food products without significant loss of flavour, colour, taste and nutrients.

Introduction

The quality and safety of food products are the two factors that most influence the choices made by today's increasingly demanding consumers. Pulsed Electrical Field (PEF) technology is based on the phenomenon that biological membranes are punctured when an external electrical impulse is applied. This process is often referred to as non-thermal as structural damage to membranes is realized at significantly low energy levels when compared to the process of heating. It is a technique in which a food is placed between two electrodes and exposed to a pulsed high voltage field (typically 20-80 kV cm⁻¹). For preservation applications, treatment times are of the order of less than 1sec, achieved by multiple short duration pulses typically less than 5 μ s. This process reduces levels of microorganisms whilst minimizing undesirable changes in the sensory properties of the food.

Principle

PEF technology is used in the areas of genetic engineering and biotechnology to promote cell membrane reversible electroporation and cell electrofusion, respectively. The same principle is applied to PEF technology for microbial inactivation during food processing.

In PEF technology, the energy derived from a high-voltage power supply is stored in one or several capacitors and discharged through a food material to generate the necessary electric field. The energy stored in the capacitors can be discharged almost

instantaneously at very high levels of power. The discharge occurs in a treatment chamber in which the food is placed or circulates through a small gap between two electrodes. When a trigger signal is activated, a high voltage switch is closed and the charge stored in the capacitor flows through the food in the treatment chamber. In order to avoid undesirable thermal effects, cold water is recirculated through the electrodes to dissipate the heat generated by the electric current passing through the food.

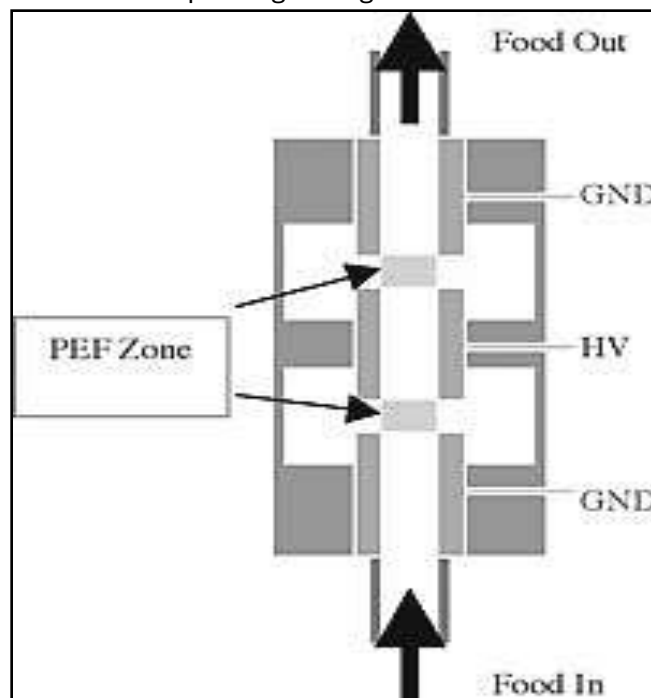


Fig. 1: Operation of Pulsed Electric Field (PEF) Processing

Working mechanism of pulsed electrical field processing (PEF)

Following two mechanisms have been proposed for inactivation of microbes using PEF:

Electrical breakdown

The bacterial cell membrane can be considered to be a capacitor that is filled with a dielectric material. The normal resisting potential difference across the membrane (the transmembrane potential) is around 10 mV. If an external electric field is applied, this increases the potential difference across the cell membrane. This increase in potential difference causes a reduction in the membrane thickness. When the potential difference across the cell reaches a critical level, pores are formed

in the membrane. This leads to an immediate discharge at the membrane pore and consequently, membrane damage (Barbosa-Canovas *et al.*, 2000).

Electroporation

When a microorganism is subjected to a high voltage electric field, the lipid bilayer and proteins of the cell membrane are temporarily destabilized. Changes in the conformation of lipid molecules are induced, existing pores are expanded and structurally stable hydrophobic pores are formed which can conduct current. This leads to localized heating that changes the lipid bilayer from a rigid gel to a liquid crystalline form (Jeyamkondan *et al.*, 1999). Once the semi permeable nature of the membrane is impaired, swelling and eventual rupture of the cell is induced.

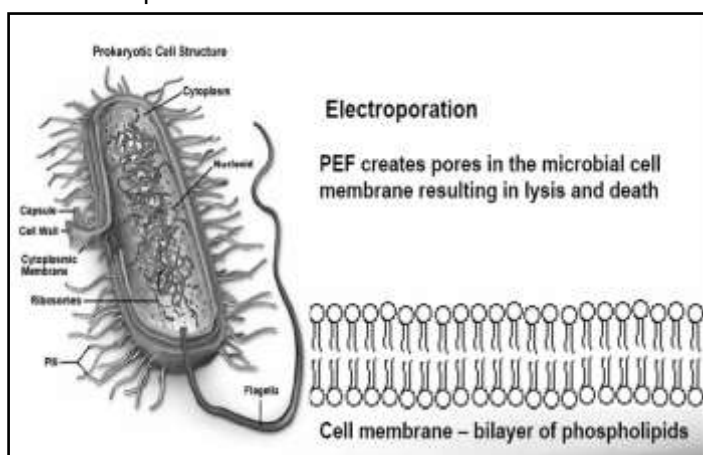


Fig. 2: Electroporation Mechanism of Pulsed Electric Field (PEF) Processing

Applications of pulsed electrical field (PEF)

1. PEF technology is used for the pasteurization of foods such as fruit juices, milk, yogurt, soups and liquid eggs.
2. It is also applied to enhance extraction of sugars and other cellular content from plant cells, such as sugar beets.
3. PEF also found application in reducing the solid volume (sludge) of wastewater.
4. It is also used to convert the non-flocculent yeast to a flocculent form (Knorr and Angersbach, 1998).
5. It can be combined with other methods like Compression (Noelia Lopez *et al.*, 2007), pressure (Bazhal *et al.*, 2001) and also ultra violet irradiation (Noci *et al.*, 2008).

Advantages of pulsed electrical field (PEF)

1. PEF is an energy efficient process compared to thermal pasteurization. A commercial-scale

PEF system can process between 1,000 and 5,000 liters of liquid foods per hour.

2. PEF processing offers high quality fresh-like liquid foods with excellent flavour, nutritional value and shelf-life.
3. Since it preserves foods without using heat, foods treated this way retain their fresh aroma, taste and appearance (Bendicho *et al.*, 2002).
4. This process uses ordinary electricity. The facility meets electrical safety standards and no harmful environmental by-products are produced.
5. It improves shelf life of a product.
6. Processing time is very less compared to other processing methods, which is nearly in micro-seconds.
7. It improves extraction efficiency of oil seeds, flavoring and colorant compounds.

Disadvantages of pulsed electrical field (PEF)

1. Application of PEF processing is restricted to food products with no air bubbles and with low electrical conductivity.
2. PEF is a continuous processing method, which is not suitable for solid food products that are not pumpable.
3. PEF installation cost is high.

Conclusion

Pulsed Electrical Field (PEF) technology is one of the recent food processing methods which not only aimed at the non-thermal food preservation but also the food safety with the retention of heat sensitive nutrients and organoleptic characteristics. PEF also useful for food industry in the ETP (Effluent Treatment Plant) to reduce the amount of excess sludge from the waste water. PEF treatment is an alternative to continuous heat pasteurization of bulk product like fruit juice and milk with technical and economic feasibility.

References

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