Food Preservation Using Pulsed Electric Field

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Abstract- *Thermal inputs for food preservation generally dominate the food processing industry. However such treatments may lead to several undesirable changes in quality attributes and nutritional value of food. On the contrary, non-thermal preservation methods have a minimal impact on the sensory quality and nutritional status of food. Several non-thermal techniques have been involved in food preservation with an objective to maintain the nutritional properties and physic-chemical characteristics of food products. In this regard, pulsed electric fields provide an alternative choice for various food products, particularly for liquid foods, for better preservation and maintenance of fresh-like quality aspects of food. Application of high-voltage electric fields at a certain level for a very short time by PEF not only inhibits pathogenic and spoilage microorganisms but also results in the retention of flavor, aroma, nutrients, and color of foods. Correspondingly, this memoir highlights the potential of pulsed electric field technology as an effective tool to preserve various foods with special reference to microbial inactivation. Additionally, principles, associated mechanistic approaches, effect of this treatment on food quality and problems linked with the consumer acceptance are also discussed in this script*

Keywords- Pulsed Electric Field (PEF), Integrated Circuit(IC), Liquid Crystal Display(LCD), Computer Aided Design(CAD)

I. INTRODUCTION

Some of the traditional food processes like cooking, freezing, refrigeration and blanching are commonly known methods which are generally used by the people in their homes. However, in the food processing industries these techniques are combined with other processing operations with the help of several contemporary process technologies by using different technical prospects that are not commonly practiced by consumers during household processing. Modern food technology deals with the development of conventional processing methods such as high-temperature short time heating or vacuum cooking, as well as several other approaches like high pressure treatment, extrusion, pulsed electric field technology and microwave processing.

A wide range of non-thermal processing techniques have gained popularity in recent times as a potential tool for the substitution or replacement of traditional thermal processing methods of foods. Additionally, non-thermal processes offer several advantages over thermal processes such as low processing temperatures, efficient energy utilization, keeping the quality of food like color, flavor, taste & nutrientretention and inactivation of quality deteriorate enzymes & spoilage causing microorganism.

Food preservation technologies are based on the prevention of microbial growth or on the microbial inactivation. Application of pulsed electric fields of high intensity and duration from microseconds to milliseconds may cause temporary or permanent permeabilization of cell membranes. The effects of PEF on bio-membranes have been thoroughly studied since the use of PEF has attracted great interest in several scientific areas such as cell biology, biotechnology, medicine, or food technology.

II. PROBLEM STATEMENT

Pulsed electric field (PEF) technology is a non-thermal food preservation method that involves the use of short electricity pulses for microbial inactivation while imposing minimal detrimental influence on food quality. This technology has the major advantage to provide high-quality foods to the consumers. Likewise, PEF is also capable of improving energy usage in an efficient and economical way. PEF is claimed as superior to thermal processing and preservation methods because it reduces detrimental changes in food quality and nutrition and keeps physical and sensorial attributes of food. Hence, successful applications of PEF technology propose an alternative to conventional thermal processing techniques for food preservation and processing.

III. RELATED WORKS

During the last decades, many novel techniques of food processing have been developed in response to growing demand for safe and high quality food products. Nowadays, consumers have high expectations regarding the sensory quality, functionality and nutritional value of products. They also attach great importance to the use of environmentally-friendly technologies of food production. Development of innovative food processing methods can increase the competitiveness of the food industry by improving product quality, introducing new products to the market and reducing

production costs. Incorporation of pulsed electric field (PEF) technology into food production was supported by the growing consumer interest in food of high nutritional value, the demand for fresh-like products as well as food produced with the use of environmentally friendly methods The aim of this review is to summarize the applications of PEF in food technology and, potentially, in production of functional food. The examples of process parameters and obtained effects for each application have been presented.

IV. METHODOLOGY

Pulsed electric field (PEF) technology is a non-thermal food preservation method that involves the use of short electricity pulses for microbial inactivation while imposing minimal detrimental influence on food quality. This technology has the major advantage to provide high-quality foods to the consumers. PEF is claimed as superior to thermal processing and preservation methods because it reduces detrimental changes in food quality and nutrition and keeps physical and sensorial attributes of food. PEF is known as one of the most auspicious non-thermal tools for microbial decontamination of foods. It involves the generation of electric fields (5-50kV/cm) with the help of short high voltage pulses (μs) between two electrodes that leads to microbial inactivation at temperatures lower than thermal methods.

A. Principle Of PEF

PEF technology involves the use of pulses having higher electric fields for only a few micro to milliseconds with intensity in the range of 10-80kV/cm. The process depends on the number of pulses delivered to the product which is held between two electrodes. These electrodes have a specific gap between them which is known as treatment gap of the chamber. During PEF processing, high voltage is applied that results in the inactivation of microorganisms present in the food sample. The electric field is applied in different forms likeas exponentially decaying waves, bipolar waves or oscillatory pulses. The process can also be carried at various temperature ranges such as ambient, sub-ambient and above-ambient temperatures. Food is packed after treatment with PEF and then stored under refrigerated conditions.

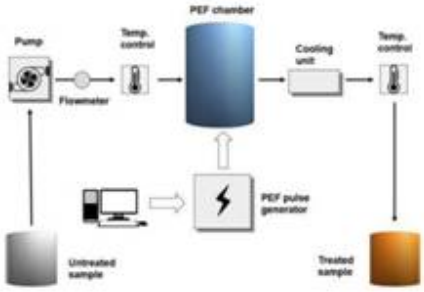

Fig.1. A typical PEF unit used in Food Processing

B. Block Diagram

A pulsed Electric Field processing system consists of a high-voltage power source, an energy storage capacitor bank, a charging current limiting resistor and a switch. An oscilloscope is used to observe the pulse waveform. The power source, a high voltage DC generator, converts voltage from an utility line (110 V) into high voltage AC, then rectifies to a high voltage DC. Energy from the power source is stored in the capacitor and is discharged through the treatment chamber to generate an electric field in the food material. The maximum voltage across the capacitor is equal to the voltage across the generator. An electrical switch is used to discharge energy stored in the capacitor storage bank across the food held in the treatment chamber. A pump is used to convey the food through the treatment chamber. 29 A chamber cooling system may be used to diminish the ohmic heating effect and control food temperature during treatment. High-voltage and high-current probes are used to measure the voltage and current delivered to the chamber.

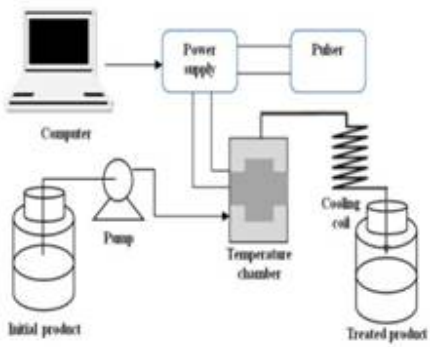

Fig.2. Block diagram of a Pulsed Electric Field Operation

C. Flow Diagram

The equipment consists of a high voltage pulse generator and a treatment chamber with a suitable fluid handling system and necessary monitoring and controlling devices. Food product is placed in the treatment chamber, either in a static or continuous design, where two electrodes are connected together with a non conductive material to avoid

electrical flow from one to the other. Generated high voltage electrical pulses are applied to the electrodes, which then conduct the high intensity electrical pulse to the product placed between the two electrodes. The food product experiences a force per unit charge, the so-called electric field, which is responsible for the irreversible cell membrane breakdown in microorganisms.

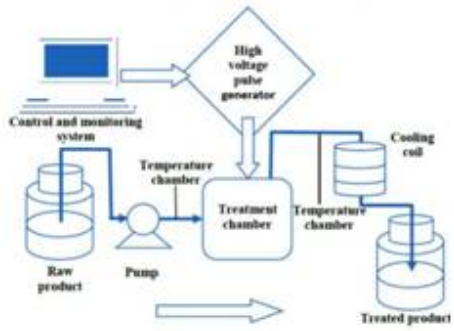

Fig.3. Flow chart of a PEF Food Processing System

V. EXPERIMENT AND RESULT

The objective of food preservation technologies used by the food industry is to control microorganisms once they are contaminating foods. Food preservation technologies are based on the prevention of microbial growth or on the microbial inactivation. Pulsed electric field (PEF) is a potential non-thermal food preservation technique to replace conventional thermal processing. When exposed to high electrical field pulses, cell membranes develop pores either by enlargement of existing pores or by creation of new ones. The pulsed electric processing system is composed basically of a high power pulse generator, a treatment cell, voltage and current measuring devices. A traditional treatment cell consists of two electrodes held in parallel by insulating material that form an enclosure containing the food to be treated.The basis for this prediction is because of PEF's ability to inactivate microorganisms in the food, reduce enzymatic activity, and extend shelf-life with negligible changes in the quality of the final product as compared to the original one. According to the intensity of the field strength, electroporation can be either reversible (cell membrane discharge).

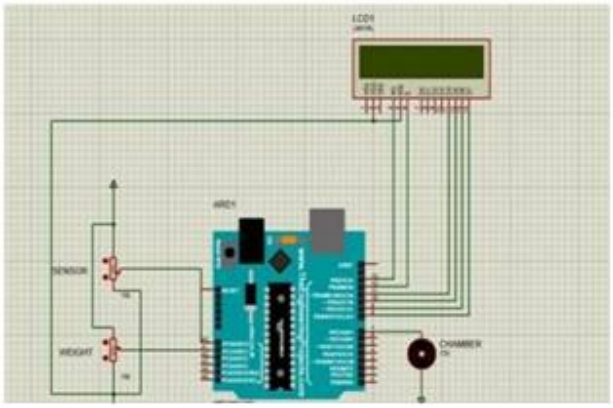

Fig.4. Screenshot of overall setup of the simulation

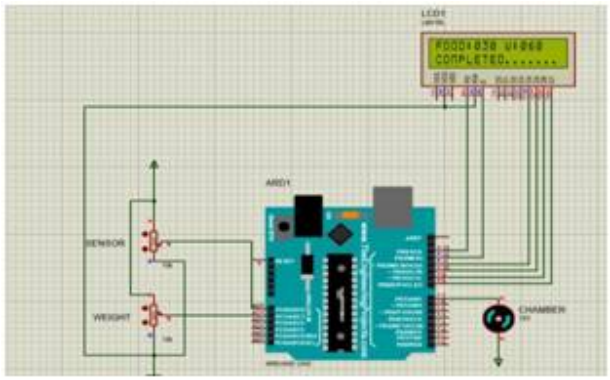

Fig.5. Screenshot indicating the completion of PEF process

Weight of the intact product (gm)	PEF Applied (%)	Status of the Intact product
40	60	Completed
50	70	Completed
60	80	Completed

Fig.6. Table containing the output of the PEF process

VI. CONCLUSION

Pulsed electric field technology is a quite effective approach for the preservation and processing of a variety of food products without much affecting their quality attributes. Though, research on PEF as a non-thermal technique should not be limited only towards microbial inactivation but also towards the retardation of several spoilage inducing chemical and enzymatic reactions, retention of functional components in food during and after treatment.

REFERENCES

[1] Front. Bioeng. Biotechnol, "Perspective on Pulsed electric field treatment in the Bio-based industry", 2019.

[2] Ostermeier R, Gersmehl P, Siemer C, Töpfl S, Jäger H, "Influence of pulsed electric field (PEF) pre-treatment on the convective drying kinetics of onions", Journal of Food Engineering, 237, 110-117, 2018.
[3] Fauster T, Schlossnikl D, Rath F, Ostermeier R, Teufel F, Toepfl S, Jaeger H, "Impact of pulsed electric field (PEF) pretreatment on process performance of industrial French fries production", Journal of Food Engineering, 235, 16-22, 2018.
[4] Qamar Abbas Syed, Anum Ishaq, Ubaid Ur Rahman, Sadia Aslam, Rizwan Shukat, "Pulsed electric field technology in food preservation", Journal of nutritional health and food engineering, Volume 6, Issue 6, 2017.
[5] Reineke K, Schottroff E, Meneses N, Knorr D, "Sterilization of liquid foods by Pulsed electric fields - an innovative ultra-high temperature process", Front Microbiol 6: 400, 2016.
[6] Siemer C, Aganovic K, Toepfl S, "Application of PEF in foods, conventional and advanced food processing technologies", pg: 645-672, 2015.
[7] Abenoza M, Benito M, Saldana G, Alvarez I, Raso J, Sanchez-Gimeno AC, "Effects of pulsed electric field on yield extraction and quality of olive oil", Food and Bioprocess Technology, 6, 1367–1373, 2013.