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Application Of Pulsed Electric Field In Inactivation Of Microbial Organisms

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Abstract Pulsed electric field treatment is used in various field in electrical aspects among the various uses inactivation of microorganism using PEF treatment has many advantages than conventional method of inactivating bacteria. This method helps to improve the shelf life of liquid food than usual heat pasteurizing technique. Its main aim is to inactivate the micro organisms present in food without affecting the physical and chemical nature of the food

Index terms:PEF-pulsed electric field, pasteurizing.

I Introduction

In traditional method of food preservation chemical additives and heat pasteurizing technique are used which decreases the bacterial growth in the food material. But using this method the nature of food material will be reduced in taste, colour and odour. Therefore in this paper we are using pulsed electric field treatment to reduce the bacterial growth in food and also to retain the nature of food after treatment.

Inactivation effect of PEF on microorganism and enzyme has been extensively studied over the past few years. The extent of microbial destruction in PEF-treated juice has beenreported to be related to several factors such as electric fieldstrength, treatment time, pulse width, frequency, and polarity.

Non-thermal food preservation methods have generated considerable interest in the food industry for their potential to offer an alternative to the traditional thermal processing methods. One of these non-thermal methods is Pulsed Electric Field (PEF) method. It involves the application of pulses of high voltage to liquid or semi-solid materials, placed between two electrodes at ambient, or slightly above ambient temperature. Many studies have been conducted to investigate the effect of different factors on the efficiency of applied PEF for microorganism inactivation. Among these factors are electric field vel, number of pulses, pulse width and type of microorganism. Most of the studies have been carried out using either buffer solutions or liquid food inoculated with known microorganisms.

An optimum combination of pulse magnitude and width is critical in inactivating microorganisms using PEF to achieve a high killing efficiency. Medium conductivity has significant influence on the inactivation of microorganisms.

Heat pasteurization or sterilization of liquid foods is the traditional method used to inactivate spoilage microorganisms that might grow under conditions normally encountered in storage and the treated product has adverse affect in the color, flavor, taste and its nutritional value causing irreversible loss of fresh flavor, aroma and its texture with initiation of undesirablebrowning reactions [3].

Moreover, heat pasteurization is an energy intensive method. Due to these reasons, we go for non-thermal processing method such as high voltage pulsed electric field treatment which provides consumers with microbiologically safe and fresh quality foods without any loss of its quality and nutritional value [4].

There are several non-thermal pasteurization methods available in general. Among this High voltage pulsed electric field (PEF) treatment is the most promising non-thermalprocessing method that may radically change liquid food preservation technology [5].

This method is been developed to achieve sufficient microbial reductionwithout much affecting the quality of food preserved. Applying PEF technology to food preservation offers highquality fresh-like liquid foods with excellent flavor, nutritional value, and shelf-life. Since it preserves foods without using heat, foods treated this way retain their fresh aroma, taste, and appearance.

II POWER REQUIREMENTS

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The treatment chamber can be considered as a purely resistive load ***R*** as the productRC is much smaller than the considered pulse duration. Here C is capacitance of the electrodes which can be neglected. The required peak power for PEF technology at an industrial scale is one of the limiting factors, where the power increases with the
flow rate ***Q*** (m'hr) [8].The theoretical lower limit for the required peak power at the chamber terminals can easily be calculated from:

$$P_{min} = \sigma E^2 V_{ch} \quad ...(1)$$

with ***Vch*** thevolume ofthe treatment zone (shortly referredto as 'chamber'), E the field strength and the σ specific conductivity ofthe food.The chambervolume ***Vch*** is calculated from the product of cross section and chamber length

$$V=(\pi/4)D^2 L...(2)$$

where D is the diameter of a cylindrical supposed chamber. The minimum value of the required diameter ***D*** can becalculated from the flow rate Q (d / s) and the maximum allowable flow velocity ***v***

$$Q=(\pi/4) D^2 v \quad ...(3)$$

It is further assumed that the ratio between chamber length L and diameter ***D*** is constant with *L*=.*W*. From (2) and (3) the following relation betweenflow rate and minimum chamber volume as a function of flow rate can be obtained

$$V=(2kQ/ v) * (\sqrt{(Q/ \pi v)}) \quad ...(4)$$

The required power can now be expressed as a function of flow rate, conductivity, and field strength

$$P_{min}=(2k \pi \sigma E^2) (\sqrt{(Q/ \pi v)})^{(3/2)} \quad ...(5)$$

This equation clearly shows which parameters affect the power, where the effect of field strength is dominant. Further the power increases more than proportional with the flow rate Q.

III CIRCUIT FOR IMPULSE GENERATION

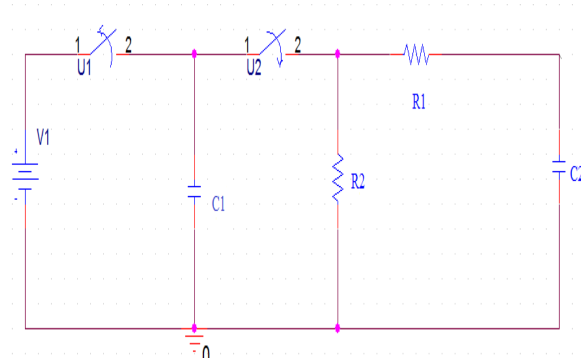

Fig1: Single Stage Marx Circuit

The above circuit is single stage Marx circuit used to generate impulse waveform which is used to deactivate the bacteria. The waveform generated should be as per the IEC standards. The capacitor C_1 is previously charged to a particular DC voltage and suddenly discharged in to the wave shaping network through the sphere gap arrangement. The discharge voltage across the capacitor C_2 gives rise to the desired double exponential wave shape. The desired wave shapes are obtained by controlling wave shaping resistors (R_1 and R_2).C_1 is the impulse capacitance, R_2 tail resistance, R_1 front resistance and C_2 is capacitance of load and voltage divider. Since the tail time is long for impulse voltage always R_2 is chosen higher than R_1.

As per IEC (60060-1) standard the front time of generated impulse wave should be 1.2µs and tail time of 46.20µs.

Thefront time (t_f)

$$t_f =3R_1 (C_1C_2) / (C_1+C_2) \quad ...(6)$$

Thetail time(t_t)

$$t_t=0.7(R_1 +R_2) (C_1+C_2) \quad ...(7)$$

Procedure to inactivate micro organisms

A. Treatment Chamber

A PEF treatment occurs inside of a PEF treatment chamber, which houses electrodes and delivers a high voltage to a food material. The PEF treatment process may be either static or continuous.

A1.Static Treatment Chamber

In the static processing, discrete portions of fluid food stuff are treated as a unit by subjecting all of the fluid to a PEF treatment chamber, in which uniform

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field strength substantially is applied to all elements of

Food stuff to be treated and in the continuous processing, the food stuff is flowing into and emitted from the PEF treatment system in a steady stream by a pump and the design of the treatment chamber is a gradual development from static treatment chambers to continuous treatment chambers.

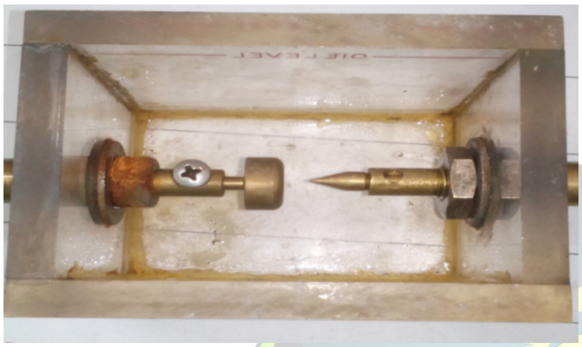

Fig2:Static treatment chamber with non uniform field electrode.

A2. Continuous Treatment Chamber

Coaxial and the co-field continuous PEF treatment chambers are widely used due to their simplicity in structure. Electrical current flows perpendicularly to food flow in coaxial PEF treatment chambers and in parallel to food flow in co-field flowPEF treatment chambers.[6]

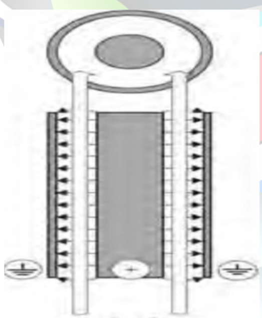

Fig3:Coaxial field chamber

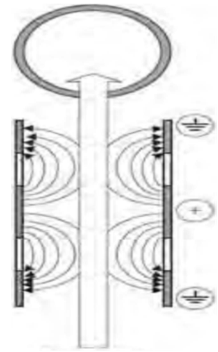

Fig4:Co field chamber

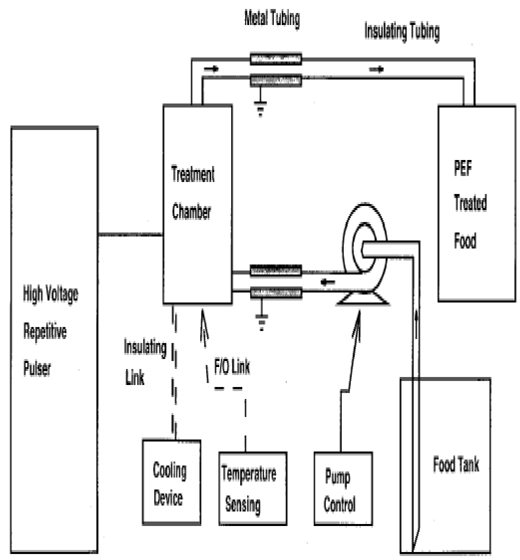

Fig 5: continuous PEF process system for inactivation of microorganisms in liquid foods.[9]

IV EVALUATION

The count of bacteria in pulsed field treated juice is found to be decreased than untreated juice[10]

Table 1

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MICROBIAL CONTENT OF FRESHLY SQUEEZED ORNAGE JUICE

Item	Unpulsed juice	Pulsed juice
General microbial count (acid tolerant bacteria, molds and yeasts)	8.0×10^8	7.7×10^8
Lactic acid bacterial count	1.7×10^7	1.1×10^3

From the above result the bacterial count is decreased[10].

Table 2
CONTINUOUS PROCESS MICROBIAL TEST RESULT

SAMPLE	MICROBIAL COUNT		% GROWTH
	1ST DAY	7TH DAY	
Control Sample	6940	9680	28
30kV, 150 Pulses	1050	1300	19
50kV, 150 Pulses	560	670	16
50kV,300 Pulses	340	380	11
50Kv, 300 Pulses (–ve)	330	370	11

The above table 2 shows the micro organism reduces after application pulsed electric field as well as by increasing electric field from 30KV to 50 KV,the count of the microbes also found to be decreasing.For negative impulse under 50KV when compared to positive impulse under 50KV is analyzed to be more efficient[7].

V CONCLUSION:

In this paper we have analyzed the use of pulsed electric field in inactivating the bacterial growth in liquid food. From the above results the high electric field, pulse width, pulse number and uniformity of field act as factor in reducing the microbial growth.
High intensity pulsed electric fields (PEF) is one of the bestnon-thermal treatment system than pasteurization of liquid foods. Major components in the system included a high voltage repetitive pulse generator, coaxial liquid food treatment chamber, fiberoptic temperature instrument, and data acquisition systems.

Chemical properties - pH, Acidity, color and size valuewill remain almost same inboth controlled and testedsamples of both static and continuous treatments.
Compared with treatments in batch systems, the continuous flow system more efficiently inactivated microorganisms. To obtain microbiologically safe, minimally processed, fresh-like food products, further research is necessary to assure safe and uniform non-thermalpasteurization of liquid foods in pulsed electric fields.

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