

Electrical Sterilization of Juice by Discharged HV Impulse Waveform

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Abstract: In the sterilization system by using HV impulse waveform, apple juice was sterilized with HV discharged oscillatory decay waveform. The optimal condition of impulse waveform for electrical sterilization has presented the excellent condition at 40kV cm^{-1} , 4mH and over. The characteristics of this waveform shows oscillatory decay waveform with multiple pulses. And this impulse waveform was more effective to kill *S. Cervisiae* than exponential decay waveform. *S. Cervisiae* to become musty and sour for apple juice was used as the sample. This apple juice has good effect of electrical sterilization because of higher conductivity than water. Therefore this experiment can be treated sterilization without loss of vitamin C and original taste or perfume to apple juice. As a result, it is found that apple juice can be sterilized on 40kVcm^{-1} , 4mH and over by using our designed HV impulse sterilizer.

Key words: Sterilization, Oscillatory decay, HV impulse, *Saccharomyces cervisiae* exponential decay

INTRODUCTION

Electrical sterilization of biological cells has the advantage of conventional, chemical or thermal sterilization and has been studied by many researchers. According to Sale and Hamilton, the condition of sterilization is determined by the product of the pulse length and number of pulses and by the field strength in the suspension^[1-3]. RLC circuit with oscillating parameters, which consists of a capacitive energy storage source and a inductive pulse duration and a resistive cell suspension chamber has been widely used for a discharging network. RLC circuit shows multiple pulses(although oscillatory decaying) are available during the charging and discharging between capacitor and inductance with chamber containing cell suspension. Especially, according to our experiments results we think that this multiple pulse has the high efficiency for the same stored energy in capacitor whereas, conventional CR circuit has only single pulse is available by discharging energy stored in capacitor to treatment chamber containing cell suspension^[4,5]. Therefore the RLC condition is considered one of the most important point to be investigated for electrical sterilization by HV impulse. The authors carried out an experiment to sterilize apple juice using our sterilizer consists of RLC network. Apple juice which is one of the popular juice with orange juice or grape juice in our country. But apple juice has the limited storage life which resulted from the store because of manufacturing without fired store process or because of being microorganism contaminated by manufacturing process. And especially, what we call *S. Cervisiae* well known

to the general public as to acidify the apple juice possessed the characteristics of only well living in apple juice. So it is very important to sterilize the *S. Cervisiae* for the good quality of apple juice. Generally, in the manufacturing company, there make an attempt at improvement in the preservation of apple juice by means of heat treat. But sterilization by heating has the point at issue to be deteriorate the quality of apple juice because of oxidizing or resolving the ingredients of apple juice by heating and because of vitamin C degeneration, loss of original taste and perfume. Therefore this experiment can be treated sterilization without such a point at issue.

MATERIALS AND METHODS

Figure 1 shows schematic diagram of experimental apparatus. In pulse generator, C (=0.1uF) of condenser was charged from dc high voltage source and discharge into the electrode (=Tank) by controller. In this case, the pulsed voltage was decayed by time constant (=CR). R and C are fixed, while only L value is changeable for good condition of oscillation decay. The diameter of treatment tank is 40cm and height is 60cm. and the electrode's diameter is 20cm, and Gap distance of electrode in treatment tank is adjusted to 10cm. The pulse of applied electric field is 2kVcm^{-1} and the repetition rate of controller is operated as follows:

$T = nt$;(T; treatment time, n; number of pulse, t: pulse width), $n = (f.V)/m$;(n; number of pulse, f; number of frequency, V; volume(mL) of container, m; flux(mL/s)) and pulse width was 10us.

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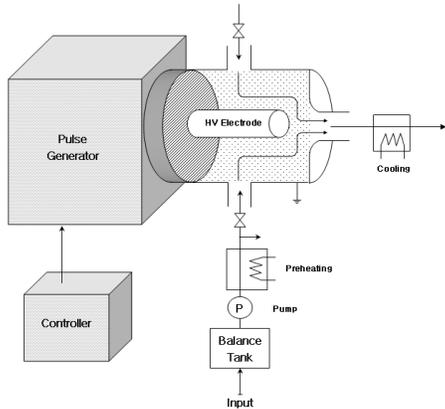


Fig. 1: Schematic diagram of HV impulse sterilizer

The *S.Cervisiae* is followed on the heels of apple juice to buy in market in order to be made 2.0×10^8 at initial number of cell. The sample in the shocked apple juice is diluted to 10^{-6} range. The 0.1ml of sample are transferred to the surfaces of Rogosa SL agar plates and spread over the surface of agar with a sterile glass rod. Then the plates are incubated at a temperature of 30° for 5 days and the numbers of colonies are counted.

Therefore the influence of HV impulse on the *S.Cervisiae* has been measured as a survival ratio ($S=N/N_0$, where N and N_0 are a number of active microbes per unit volume after and before the voltage treatment, respectively)

RESULTS AND DISCUSSION

In this experiments the energy stored in the capacitor ($1/2 C V_0^2$) is used as the energy input to the suspension by one pulse. The energy input was 31.25J at $V_0 = 25kV$ and 80J at $V_0 = 40kV$. In the same condition Fig. 2 illustrates that the survivability decrease with the change in the pulsed number. Here, the inductance value used 4mH. For example in case of 25kV the survivability decrease by 10 times of magnitude within the range of pulsed number 10 to 40 times. And in case of the same condition on 20 times, the survivability decrease by 10 times of magnitude within the range of voltage 10 to 40kV. Therefore, the more pulsed number and electric field strength are increase, the more the survival ratio is decrease.

In Fig. 3 the survival ratio of *S. Cervisiae* is shown as function of the inductance value against electric field strength. Here, the number of applied pulses was 40 times. In case of 14mH, the survivability decreases by ten millionth on $40kV\ cm^{-1}$.

For 0mH a decrease of 4 times of magnitude takes place for 5kV to 40kV. It is evident that the survivability decreases by 10 times of magnitude within the range of inductance 0 to 14mH. But in case of 4mH and over, the survivability is shown to decrease of 15 times of magnitude than that of 0mH. As shown in Fig. 3 and 4, it is found that electric field strength

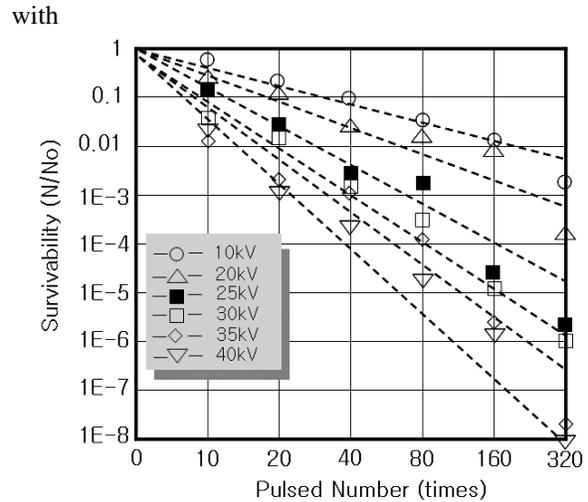


Fig. 2: Survivability on pulsed number against electric field strength

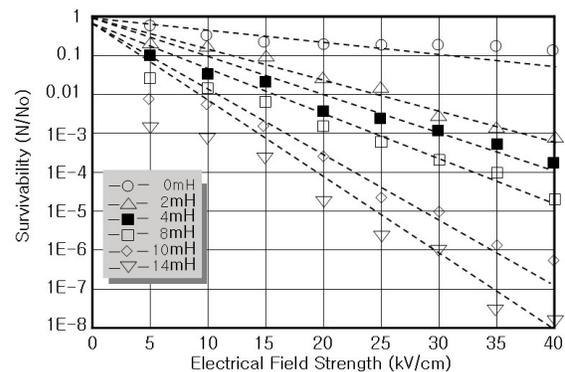


Fig. 3: Survivability on inductance value against electric field strength

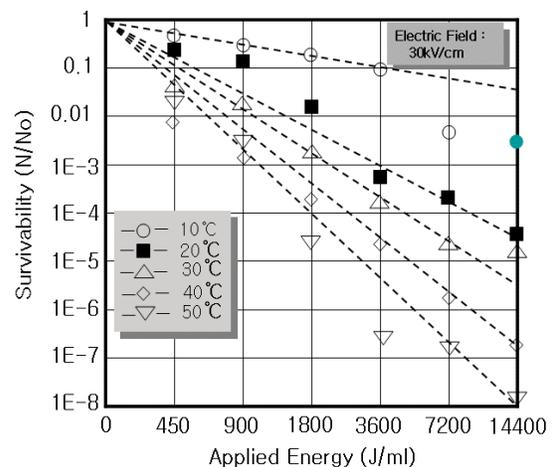


Fig. 4: Survivability on liquid temperature against applied energy

high L value has effect of sterilization on *S. cervisiae*.

And in Fig. 4 there can obtain the effect of full sterilization for $30kV\ cm^{-1}$, $14400J\ mL^{-1}$ with the applied liquid temperature of 50° . And in case of $450J\ mL^{-1}$, the survivability decrease by 80 times of

magnitude within the range of liquid temperature 10 to 50°.

CONCLUSION

In this experiment, there can obtain the effect of sterilization, 99.9999% for electric field strength of 30kV cm⁻¹ and applied energy of 14400J mL⁻¹ with applied liquid temperature of 50°. It means that the sterilization of apple juice has out and out the best in parallel with electrical sterilization and low temperature sterilization processing. And finally, it is found that the survivability of *S. Cervisiae* being tested decreases with an increase in L value of 4mH and over.

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