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, 4mH. The characteristic of this waveform shows oscillatory decay waveform with multiple pulses. And this impulse waveform was more effective to kill Saccharomyces cervisiae than exponential decay waveform. Saccharomyces cervisiae to become musty and sour for apple juice was used as the sample. Especially, Vitamin C content of electrical sterilized apple juice was close to that of fresh apple juice, but was much higher than that of heat treated apple juice. Heat treated apple juice lost 80% of flavor components, whereas electrical sterilized apple juice lost only 10%. 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 40kV/cm, 4mH by using our designed HV impulse sterilizer.

Keywords- Sterilization, HV impulse, Saccharomyces cervisiae, exponential decay

I. INTRODUCTION

Electrical sterilization of biological cells has the advantage of conventional, chemical or hernal 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]. Before we have evaluated the survival ratio of E.coli depend on the characteristics of RC and RLC circuit [2]. The result of that experiment is appeared RLC circuit better than RC circuit in E.coli sterilization [3]. RLC circuit with oscillating parameters, which consists of a capacitive energy storage source and a inductive pulse circuit better than RC circuit in E.coli sterilization [3]. RLC circuit [2]. The result of that experiment is appeared RLC circuit better than RC circuit in E.coli sterilization [3]. RLC circuit with oscillating parameters, which consists of a capacitive energy storage source and a inductive pulse circuit better than RC circuit in E.coli sterilization [3]. RLC 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 Saccharomyces 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 Saccharomyces 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.

II. EXPERIMENTAL APPARATUS AND PROCEDURE

Fig.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 2kV/cm and the repetition rate of controller is operated as follows;

\[ T = \frac{n}{f} \] (T; treatment time, n; number of pulse, f; pulse width),

\[ n = \frac{(\epsilon V) m}{(mL)} \] (number of pulse, f; number of frequency, V; volume(mL) of container, m; flux/mL/s) and pulse was 10us.

Fig.2 and fig.3 are showed that 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°C for 5 days and the numbers of colonies are counted.

Therefore the influence of HV impulse on the Saccharomyces cervisiae has been measured as a survival ratio.
( S=N/No, where N and No are a number of active microbes per unit volume after and before the voltage treatment, respectively).

III. RESULTS AND DISCUSSION

In this experiments the energy stored in the capacitor \((1/2 CV_o^2)\) is used as the energy input to the suspension by one pulse. The energy input was 31.25J at \(V_o = 25kV\) and 80J at \(V_o = 40kV\). In the same condition fig.4 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 orders 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 orders 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.5 the survival ratio of Saccharo myces 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 millionths on 40kV/cm.

For 0mH a decrease of 4 orders takes place for 5kV to 40kV. It is evident that the survivability decreases by 10 orders 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 orders than that of 0mH. As shown in figure 5 and 6, it is found that electric field strength with high L value has effect of sterilization on Saccharomyces cervisiae.

IV. CONCLUSION

In this experiment, there can obtain the effect of sterilization, 99.9999% for electric field strength of 30kV/cm and applied energy of 14400J/ml with applied liquid temperature of 50°C. 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 Saccharomyces cervisiae being tested decreases with an increase in L value of 4mH and over.

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And in fig.6 there can obtain the effect of full sterilization for 30kV/cm, 14400J/ml with the applied liquid temperature of 50°C. And in case of 450J/ml, the survivability decrease by 80 orders of magnitude within the range of liquid temperature 10°C to 50 °C.