Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 3 Issue 11, November - 2016

Effect of Electrical Sterilization on Mongolian Popular Juice Chatsargana by Electrostatic Atomization

Dorjsuren Baatarkhuu
Department of Electrical Engineering
Mongolian University of Life Sciences(MULS)
School of Engineering and Technology
Ulaanbaatar, Mongolia
elec_eng@muls.edu.mn

Dorjsuren Tuvshinjargal
Department of Machine Design
Mongolian University of Life Sciences(MULS)
School of Engineering and Technology
Ulaanbaatar, Mongolia
tuvshinjargal@muls.edu.mn

Hee-Kyu Lee
Department of Mechanical Engineering
Mongolian University of Life Sciences(MULS)
School of Engineering and Technology
Ulaanbaatar, Mongolia
heekl@hanmail.net

***Abstract*—This paper presents an experimental study to find excellent condition for sterilizing effect of Saccharomyces cervisiae on electrostatic atomization. Sterilization of Saccharomyces cervisiae in suspension has been performed by using electrostatic atomization to the suspension. Saccharomyces cervisiae to become musty and sour for chatsargana juice was used as the sample. Especially, Vitamin C content of electrical sterilized chatsargana juice was close to that of fresh chatsargana juice, but was much higher than that of heat treated chatsargana juice. Heat treated chatsargana juice lost 80% of flavor components, whereas electrical sterilized chatsargana juice lost only 10%. This chatsargana 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 chatsargana juice. The survival rate of Saccharomyces cervisiae was measured against average peak electric field, diameter of ring electrode and needle electrode. From the experimental results, it is found that the lowest survivability is checked on 37.2% at 10kV DC and the diameter of each electrode was ø40mm of ring electrode, ø0.45mm of needle electrode.**

Keywords—chatsargana juice Saccharomyces cervisiae; Sterilization; suspension; ring electrode; needle electrode;

I. 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]. Chatsargana juice which is one of the traditional popular juice with orange juice or grape juice in Mongolia country. But chatsargana 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 chatsarganajuice possessed the characteristics of only well living in chatsargana juice. So it is very important to sterilize the Saccharomyces cervisiae for the good quality of chatsargana juice. Generally, in the manufacturing company, there make an attempt at improvement in the preservation of chatsargana juice by means of heat treat. But sterilization by heating has the point at issue to be deteriorate the quality of chatsargana juice because of oxidizing or resolving the ingredients of chatsargana juice by heating and because of vitamin C degeneration, loss of original taste and perfume. Therefore this electrical sterilization can be treated sterilization without such a point at issue. In this experiment, The liquid is jetted at nozzle, make up a pole of liquid or liquid membrane and which is disunited due to factor of dynamic instability this is why there happen a water drop. On the occasion of disunion to pole of liquid or liquid membrane, a water drop is charged with induced electricity by electric field about point of disunion.

A water drop charged with electricity or the surface of a liquid is unstable because of electrostatic force and there is a phenomenon of atomization with fine water drop that's what we call the phenomenon of electrostatic atomization. Figure 1 shows schematic diagram of charged inductive electricity apparatus in water drop.

In this fig.1, the nozzle was connected ground and there is applied the voltage between inductive electrode or the nozzle. If the time of electric charge relaxation in the conductive liquid has shorter enough than the period of disunion, electric charge is distributed on the surface of water drop. As fig.1 showed, because of the electric power line starts from charge and arrived to charge, there is distributed electric charge on the surface to end of water drop when the water drop is disunited.

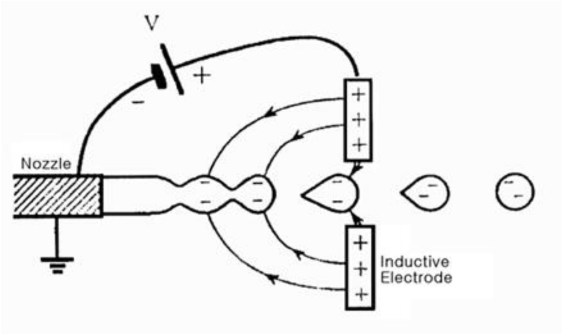


Fig. 1. *Principle of inductive electric charge.*

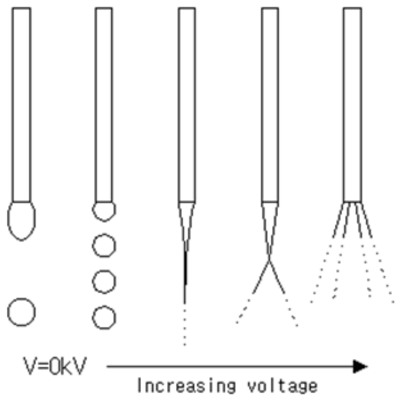


Fig. 2. *Scattering pattern of water drop from the nozzle.*

If the water drop disunited, its charge is closed into water drop and there is shaped water drop of electrical charge. Such a method of electrical charge

what we call method of inductive electrical charge. If the electric charge of inductive electrical charge is distributed on water drop or surface of liquid membrane there happens to atomization which is disunited into much fine water drop because of unstable phenomenon. To this is given the term of electrostatic atomization. Therefore, the phenomenon of electrostatic atomization is that surface tension, electric force or, if circumstances require, gravity works on an emitted liquid at the end of an injection syringe when a voltage is applied to ring electrode and injection syringe used to supply liquid [2]. Their collaboration is called a thrust; liquid is crushed into cone form as if a cone shaped mechanism [3].

As a result, according to increase in electric power and if surface tension exceeds; the liquid surface becomes unstable, and if circumstances require, a phenomenon of liquid pole comes into being. This phenomenon occurs again and again, if electric power just good for supply to liquid is supported as it is [4]. Fig.2 shows scattering pattern of water drop from the nozzle. In this fig.2, the more the voltage is increase, the more the scattering pattern of water drop is happen in nozzle. Zeleny et.al said that there happens unstable because the pressure by the charge distributed in liquid surface is negative. For this reason, respecting the atomization happens to scatter the water drop, as the following equation shows the limited voltage V_c to generate the atomization.

$$V_c^2 = cr\gamma \quad (1)$$

Here, c is constant to decide on the phenomenon of water drop, $r$is radius of water drop, and $\gamma$is surface tension of liquid.

In this paper, we study experimentally about sterilization possibility of Saccharomyces cervisiae using phenomenon of electrostatic atomization which possible to process large quantities at one time and relatively simple machinery.

II. Experimental Apparatus and Method

Fig.3 shows the experimental apparatus and the inside diameters of used syringe electrodes which end of syringe cut vertically are 0.25mm and 0.45mm. In opposite electrode, there is located 200×140mm ground metal far away 60mm from end of syringe electrode. And that electrode located on the receptacle.

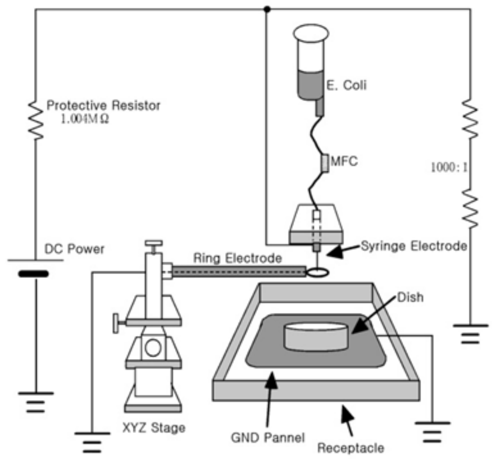


Fig. 3. *Experimental apparatus.*

In order to get the stable electrostatic atomization, there is located on the same height of the end of syringe electrode and the center of ring electrode which inside diameters are 20 mm and 40 mm and thickness of wire is 2mm. The syringe electrode is connected with DC HV Source (Dong Hwa Instrument Co., APL-20K05P,0~20kV.0.5mA).

The applied voltage used 10000:1 voltage divider and measured with multimeter [4].The samples pick up the 0.1ml of solution which is the diluted solution of Saccharomyces cervisiae (1×109/ml: growth during 24hour with 360C on the TS broth) with1to100 and adulterated Saccharomyces cervisiae solution. Also the cell suspension, which is 0.1ml of diluted solution was injected into the syringe. After atomization, the sample selected 0.1ml from receptacle and adding 0.1ml samples to the 0.9ml of 0.9% NaCl solution. For the enumeration of colony, dilutions in the range10-1(1/10) to10-7 (1/10,000,000) are used. The 0.1ml of samples are transferred the surfaces of Desoxy cholate agar plates. The samples are spread over the surface of agar with a sterile glassrod. Then the plates are incubated at atemperature of 350C for 24hour and the numbers of colonies that develop are counted. Therefore the influence of Electrostatic Atomizationon Saccharomyces cervisiae has been measured as a survival ratio(S=N/N0, where N and N0 are a number of active micro besper unit volume after and before the voltage treatment, respectively).

III. Result

Table 1 and 2 shows volume of flowing suspension on experiment. Though the volumes of flowing suspension have a tendency to slight decrease following applied voltage, in case of 0.45mmø syringe electrode, there is a slight tendency to uniformity.

Table 3 shows number of colony using syringe electrode's inside diameter of 0.25mm and table 4 appears that of syringe electrode's inside diameter of 0.45mm.

TABLE I. Volume of Flowing Suspension Using Inside Diameter 0.25mm (g/s)

Applied voltage [kV]	Inside diameter 20mm ring electrode	Applied voltage [kV]	Inside diameter 40mm ring electrode
0	0.047	0	0.047
5	0.046	4	0.046
6	0.034	6	0.044
7	0.026	8	0.037
8	0.023	10	0.026

TABLE II. Volume of Flowing Suspension Using Inside Diameter 0.45mm (g/s)

Applied voltage [kV]	Inside diameter 20mm ring electrode	Applied voltage [kV]	Inside diameter 40mm ring electrode
0	0.150	0	0.150
5	0.151	4	0.151
6	0.150	6	0.154
7	0.146	8	0.149
8	0.121	10	0.121

TABLE III. Colony number using inside diameter 0.25mm

Applied voltage [kV]	Inside diameter 20mm ring electrode	Applied voltage [kV]	Inside diameter 40mm ring electrode
0	255	0	255
5	190	4	160
6	165	6	146
7	154	8	124
8	135	10	104

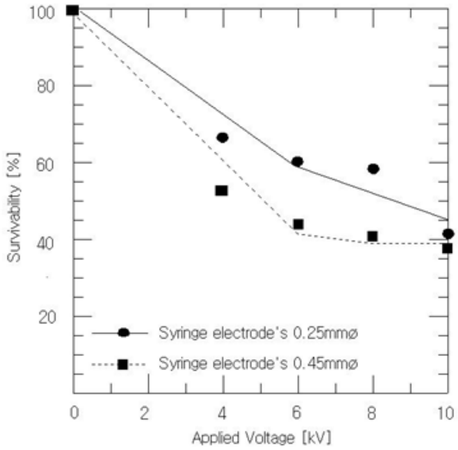
TABLE IV. Colony number using inside diameter 0.45mm

Applied voltage [kV]	Inside diameter 20mm ring electrode	Applied voltage [kV]	Inside diameter 40mm ring electrode
0	325	0	325
5	241	4	167
6	234	6	146
7	226	8	128
8	207	10	121

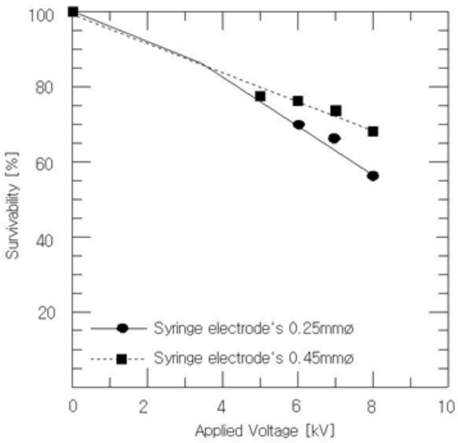
Fig.4 shows the results of survivability for the syringe's inside diameter against each applied voltage. In case of ring electrode's inside diameter of 20mm, there could not find any difference of survivability attendant upon syringe's inside diameter does, on the contrary, in case of ring electrode's inside diameter of 40mm, 0.45mm of syringe electrode's shows lower survivability.

But it seems to make little difference in disregard of increasing applied voltage. Fig.5 is shown to compare with ring electrode's inside diameter. In this figure, there is obtained lower survivability in time of using syringe electrode's inside diameter of 0.25mm and 0.45mm, ring electrode's inside diameter of 40mm.

The condition of minimal survivability in this experiment obtained 37.2% of survivability on the syringe electrode's inside diameter of 0.45mm, the ring electrode's inside diameter of 40mm, 60mm height from the end of syringe to the opposite electrode, and 10kV of applied voltage.

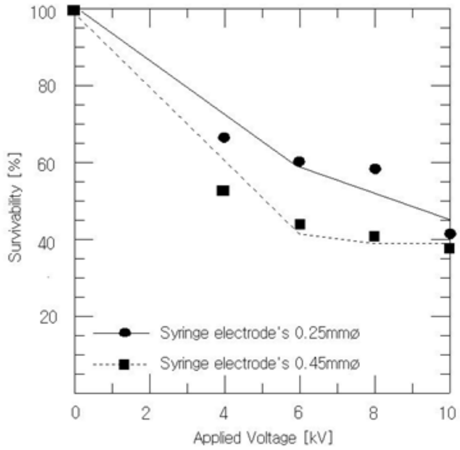


a) Ring electrode's inside diameter of 20mm

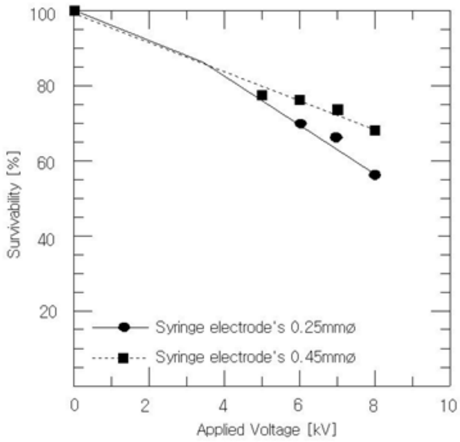


b) Ring electrode's inside diameter of 40mm

Fig. 4. *Survivability depends on ring electrode's inside diameter.*



a) Syringe electrode's inside diameter of 0.25mm



b) Syringe electrode's inside diameter of 0.45mm

Fig. 5. *Survivability depends on syringe electrode's inside diameter.*

IV. CONCLUSION

It seems that the phenomenon of electrostatic atomization is much concerned in sterilization effect. It is considered that the compared data of syringe electrode's inside diameter in Fig.4 is shown the range of scatter. In this case of microorganism manipulation, because it is nothing extraordinary that the experimental results is scattered by the condition of cultivation. In regard to the effect of ring electrode's inside diameter, there is obtained lower survivability on the side of larger inside diameter in the same applied voltage. It should be noted that the phenomenon of electrostatic atomization does not affect only the applied voltage but also the syringe electrode's inside diameter, the volume of suspension, the size of ring electrode and the position of ring electrode.

REFERENCES

[1] U.Zimmermann,"ElectricalBreakdown, Electropermealization and Electrofusion", Rev. Physiol. Biochem. Pharmacol., Springer Verlag, vol.105, pp175-265, 1986.

[2] D.Michelson, Electrostatic Atomization, Hilger, New York, 1990, p.135.

[3] A.Gurave, T.Kodas, T.Pluym, Y.Xiong, Aerosol Sci. Technology.19 (1993) 411.

[4] K.Asano, J. Electrostat. Japan 8 (1984) 182.

[5] Hee Kyu Lee, J.of Electrostatics, vols.51-52 (2001) pp71-75.

[6] U.R.Pothakamury,A.Monsalve-gonzalez, G.V.Barbosa-Ca'novas, and B.G. Swanson, "Inactivation of Escherichia coli and Staphylococcus aureus in Model Foods by Pulsed Electric Field Technology",FoodPreservationProceedings, Natick, MA,1994.

[7] Boleslow Mazurek, Piotr Lubicki "Effect of Short HV Pulses on Bacteria and Fungi", Acryl IEEE Trans. on Dielectrics and Electrical Insulation vol.2, No.3, June, 1995.