Data Analysis of Sterilization Effect of Low Pressure Pulse Magnetic Field on Fruit Juice Products

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Abstract: This study verified the sterilization effect of the low pressure pulse magnetic field on the fruit juice products. According to the sterilization effect test of low pressure pulse magnetic field equipment on fruit juice, the results showed that the low pressure pulse magnetic field possessed a bactericidal effect on fruit juice, and the sterilization effect improved with time increasing. This study has sought a new way for food companies to deal with the sterilization to fruit juice products.

Introduction

The fruit juice contains many organic components, and high temperature sterilization and pasteurization has been considered as the most commonly used non-toxic, harmless sterilization method. However, these two methods can easily lead to the loss of effective nutrient components in fruit juice because these methods would change the temperature of the fruit juice to achieve the sterilization effect. Pulsed magnetic field sterilization is a new kind of physical cold sterilization technology, which has the characteristics of low temperature rise of bactericidal material, low power consumption, no magnetic leakage, high efficiency, high sterilization efficiency, easy control, strong penetrating ability and thorough sterilization. This technology is now widely used in the circulating water sterilization of air conditioning refrigeration system. The pulse magnetic field sterilization has a broad market potential in the cold sterilization technology because the method dose not need heat and costs less time[1-2]. A large number of studies have indicated that high strength pulsed magnetic field sterilization has important application value in liquid food sterilization industry. But in the current pulse magnetic field device of air conditioning system circulating water, the applied discharge voltage is too high, generally from thousands of volts to tens of thousands of volts[3]. Such a high voltage has brought great inconvenience to the operator and safety performance is also relatively poor, therefore, these problems have hindered the research and development of pulse magnetic field in the field of sterilization and limited its application and promotion in food industry.

This paper emphatically researched the effect and application of low pressure pulse magnetic field on the fruit juice sterilization and this can provided reference for the research on the sterilization technology of fruit juice under low pressure pulse magnetic field.

Materials and methods

Materials

The principle of low pressure pulse magnetic field sterilization apparatus is shown in Figure 1, which mainly includes two parts of the pulse electric field and the pulse magnetic field. The pulse current originated from pulse magnetic field system generated high intensity

pulse magnetic field according to the solenoid coil of magnetic field system, which could kill bacteria in the materials. Electromagnetic field sterilization is utilizing electromagnetic energy to destroy or affect the structure of the organism to achieve the purpose of eliminating or inhibiting organism. Pulse magnetic field is a kind of electromagnetic field, and in the process of sterilization of material it would produce a variety of electromagnetic effects, which mainly included induced current effect, Lorenz force effect, oscillation effect, ionization effect and so on, and these electromagnetic effects can cause cell biological effects, resulting in an important influence to the sterilization process. When the pulse magnetic field sterilized, the duration of each pulse is very short, generally for a few microseconds to a few milliseconds, and several pulses can make the material sterilization rate reached 90% or more[4]. Instantaneous sterilization is carried out under normal temperature and pressure by pulsed magnetic field, and the process consisted of 4 main elements: the magnetic field intensity of the coil, pulse number, pulse current waveform characteristics and material characteristics.

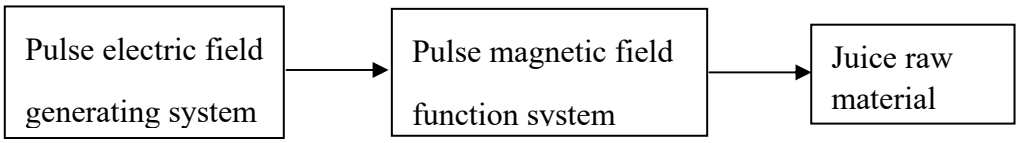

Figure 1 Principle diagram of low pressure pulse magnetic field sterilization test apparatus

The pulse electric field generating system is the main part of low pressure pulse magnetic field sterilization device, as shown in Figure 2, which mainly consisted of charging circuit part, discharge circuit part and control part.

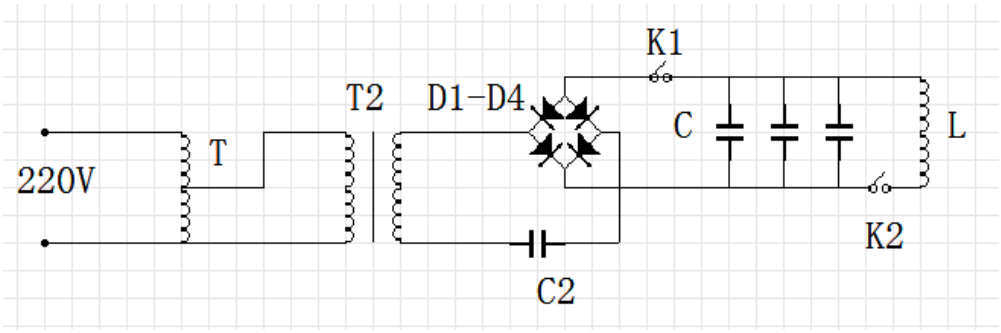

Figure 2 Circuit diagram of pulse electric field sterilization system

The charging circuit part mainly included voltage regulator, voltage booster, rectifier, current limiter, charging switch and capacitor, etc. The specific work process of charging is that 220V alternating current changed into the alternating current met the requirements of the voltage and current, according to voltage regulator T, and then through the boost transformer T2 and capacitor C2 limit current in turn. The alternating current was rectified to be a direct current power source through high voltage silicon rectifier stack. When the charging switch K was closed, the direct current power charged to the capacitor group, when the charging switch K1 was disconnected, the charging was over. The energy of the capacitor storage can be calculated by Equation 1:

$$E_c = \frac{1}{2} C U_c^2 \tag{1}$$

where E_c is the energy stored in the capacitor, C represents the capacitor, and U_c is the charge voltage of capacitor. Formula 1 indicates that Ec increases with the increase of U_c and C. Low charge voltage can not only make the electrolytic capacitor store more energy in the unit volume or the unit weight, but can also ensure the safe operation. Therefore 4 electrolytic capacitors of 20000 μF were chosen in the experiment, and the charge voltage was continuously adjustable in the range of 0 ~ 450 V using the low voltage charging technology,

the maximum energy of single pulse was 4.05 kJ. The charging mode of current limited by capacitor had the advantages of high energy utilization compared with the charging mode of current limited by resistance, so the mode of current limited by capacitor was adopted in this paper to improve the charging efficiency. Due to the high power of pulse power supply, 360 μF of the AC capacitor was selected as the current limiting capacitor in order to improve the charging efficiency, and the average charge current was generally within the range of 20 ~ 30A.

Experimental methods

Experiments were carried out in the juice processor with each test of 30mL lactobacillus, colibacillus, mildew and microzyme, respectively, and after the juice contained bacteria or fungi was mixed equably, the static sterilization test of continuous 6h was carried out under different voltage. During the experiment, one sample of 1 mL was taken every 1 hour, and the juice was diluted under the dilution fators of 10^{-4}, 10^{-5} and 10^{-6}. The asepsis state juice was moved to the culture dish, and then the pre sterilized agar medium was added. After the cooling and solidification of the mixture, the culture dish was placed in the culture box under the temperature of 30 °C for 36 h, and the colony count was recorded.

Results and discussion

Experiment 1 The influence of load voltage on sterilization effect

The magnetic field controlled circuit voltage to research the influence of sterilization rate, and 12V, 14V and 16V pulse voltage is respectively applied to the microzyme used as the research object to carry out the sterilization experiment, the results were shown in table 1:

Table 1 Relational tables of sterilization effect and load voltage

Sterilization time (h)	Load voltage		
	12V	14V	16V
1	19.82%	25.41%	29.16%
2	37.74%	47.38%	51.33%
3	56.67%	66.95%	70.49%
4	69.01%	78.71%	82.76%
5	77.87%	84.94%	88.92%
6	85.62%	89.04%	91.65%

As shown in the above table, the sterilization effect of pulsed magnetic field improved with the sterilization time whatever voltage was loaded. The comparison of three kinds of different voltage indicated that the higher the voltage loaded, the higher the sterilization rate was. The reason was that the higher the voltage loaded, the stronger the magnetic field strength was, and then the role of the penetration of microorganisms became more strengthen, resulting in improvement of the sterilization efficiency.

Experiment 2 The influence of different bacteria sterilization effect

When 16V pulse voltage was loaded, the sterilization effect comparison of lactobacillus, colibacillus, mildew and microzyme was shown in Table 2.

From table 2, we can see that the pulse magnetic field had sterilization effect on the above bacteria, and the sterilization effect gradually improved with the increase of sterilization time. It is worth noting that the sterilization effect of pulse magnetic field on bacteria such as lactobacillus and colibacillus was better than the effects on fungi such as mildew and microzyme. This was the result of the tolerance difference between the bacteria and the fungus. The cellulosic cell wall of fungi had a strong protective effect, but the toughness of

cell wall in bacteria is less than that of fungus, and thus the tolerant ability of bacteria was poorer than that of fungi.

Table 2 Sterilization effect comparison of various bacteria

Sterilization time (h)	Bacterial species			
	Lactobacillus	Colibacillus	Mildew	Microzyme
1	37.32%	34.21%	21.41%	29.16%
2	61.21%	59.54%	29.23%	51.33%
3	82.34%	80.26%	41.65%	70.49%
4	91.65%	87.21%	56.31%	82.76%
5	95.32%	91.21%	64.32%	88.92%
6	97.75%	95.43%	78.43%	91.65%

Conclusion

The experimental results showed that the pulse magnetic field sterilization method can effectively kill the bacteria and fungi in the fruit juice under the premise of retaining the nutritional components of fruit juice compared with high temperature sterilization. The effect of sterilization is proportional to the time of sterilization, and the sterilization effect of bacteria is better than that of the fungus. The research on the low voltage electromagnetic pulse sterilization method would promote the non thermal sterilization of the pulse magnetic field fruit juice to the industrial application.

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