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Investigation of Disinfection Effect for Particulate Food by Dielectric Barrier Discharge using Rotational Electrode

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1. Introduction

Heat sterilization is used as sterilization method of the most common in general food. However, heat sterilization causes degradation of food taste and flavor because particulate food material is easily affected by heat. Thus, non-equilibrium atmospheric pressure plasma has been applied as a new disinfection method to solve this problem [1].

The purpose of this study is to develop low-temperature sterilization process for particulate food using a plasma with keeping the quality of food nutritional component. In our previous research work, disinfection rate was evaluated for buckwheat powder with bacillus cereus. However, the disinfection rate was relatively low because the buckwheat powder was not dispersed and overlapped each other in the vessel. That overlapping might prevent reactive species generated in a plasma from contacting most buckwheat powder effectively. In this research, we developed Rotational Electrode Dielectric Barrier Discharge Reactor (RE-DBDR), which can treat the buckwheat powder in dispersion state using a generated rotational plasma.

2. Experimental Setup

RE-DBDR is shown in Fig. 1. High Voltage (H.V.) electrode is not connected to metal axis directly. Outside cylindrical electrode wound around reactor on upper and lower. Each outside electrode is connected to H.V. and GND. In this case, inside metal blade is connected by electrostatic induction. Plasma is also generated by induced charge between blade edge and inside wall by DBD. This method enables to control the rotational speed in a wide range without electrode wear caused by arc discharge. Metal blade (20 mm×1 mm×68 mmφ) is mounted in vessel made from Polyoxymethylene (POM) to disperse the powder. The inner diameter of vessel is 70 mm. High power DC motor (12 V-4.9 kg/cm-18800 rpm) is power source for rotating metal blade. Buckwheat powder (3 g) is introduced to the vessel. DC voltage applied to high power DC motor to rotate the metal blade (5800 rpm). N_2, Air gas (0.3 slm) is introduced from the bottom of reactor to top of reactor. Reactor wall 2 mm thick is used for dielectric. Applied H.V. is V_{p-p}= 28 kV. Plasma irradiation time is set as 10 min. Plasma is generated between blade edge and inside wall by DBD. Air plasma is shown in Fig. 1 with rotation or not. Plasma area is enlarged in eyesight by rotation. Following the standard methods of analysis in food safety regulation, the number of bacteria is evaluated by colony counting method.

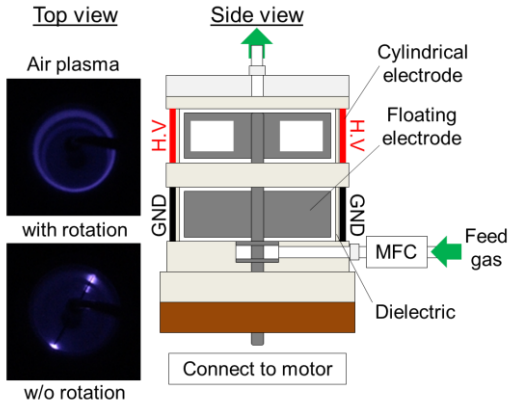

Fig. 1: Rotational Electrode Dielectric Barrier Discharge Reactor (RE-DBDR)

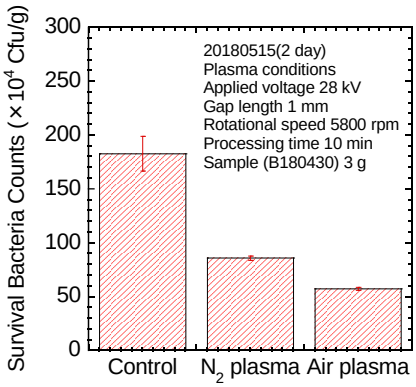

Fig. 2: Disinfection effect of He, He/N_2 (2%), He/N_2 (6%) plasma using RE-DBDR

3. Results and discussion

Disinfection effect for buckwheat powder using RE-DBDR is presented in Fig. 2. This result shows that the number of survival bacteria counts decreased to 47%, 31% after N_2, Air plasma treatment in 10 min. However, the number of bacteria counts after N_2, Air plasma treatment has not significantly changed. In general, it is considered that spore is resistant to ozone. In N_2 plasma treatment, it is confirmed that spore is sterilized by other excepting ozone.

4. Reference

[1] Syuhei Hamajima et al., "Low-Temperature Disinfection of Tea Powders Using Non-equilibrium Atmospheric Pressure Plasma", Recent Global Research and Education: Technological Challenges, vol 519., pp. 269-275, 2017