DBD and GlidArcs in Plasma Agriculture and Food Safety

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Abstract: We have developed and validated two new technologies to address the emerging problem of foodborne illnesses through cross-contamination of fresh produce during preparation and processing. Water droplets, treated in a uniform pulsed dielectric barrier discharge system show significant pathogen reduction in large volume (produce storage, for example); while reverse vortex gliding arcs are shown to be effective in large-volume water treatment, enrichment, and decontamination.

Keywords: disinfection, water treatment, water cleaning, plasma agriculture, food safety

Food safety is the ever-expanding global need. An important concern is the presence of bacteria and other pathogens on the surface of fresh produce. Plasmas, of course, are well-known for their strong antimicrobial properties. In the field of plasma medicine, a number of discharges have already been developed where plasma can successfully come in contact with living tissue, without damaging it, and achieve the desired rate of pathogen inactivation—usually within a few seconds of treatment. However, delivering plasma treatment to a 3-dimentional complex surface of foodstuffs, specifically of fresh produce, can be quite challenging: produce surface is complex and frequently multi-layered (e.g. a bag of spinach leaves), and the industrial processing rates are very high. For this reason, we have developed two systems to address this issue: 1) plasma jet-like system where an air stream containing small droplets of water is passed through the discharge and onto the surface of produce; and 2) gliding arc plasmatron system used for treatment of large volume of flowing liquid (the liquid is subsequently used for produce washing). The key challenges, addressed in this talk, are the control of temperature of air and water passing through the discharge, and the resulting chemistry generated in the liquid.

DBD misting system

Scale-up version of the DBD misting system previously described by the authors was constructed from three quartz-covered cylinders where water mist was passed between the electrodes and then onto the fresh produce. Fig 1 shows the photograph of the system and Fig 2 shows the general schematic of the treatment.

Fig 1. Photograph of the 2,500 in³ DBD misting system

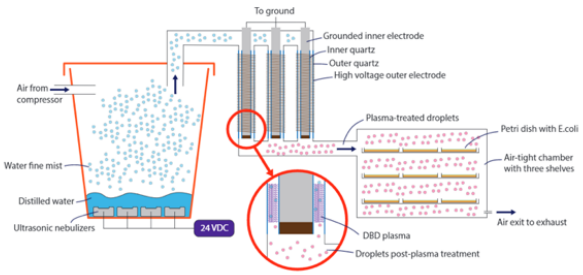

Fig 2. Schematic of the 2,500 in³ DBD misting system

Results of the plasma treatment of tomatoes, spokes with *E.coli* O:157 H7 (10^6 cfu per tomato) are shown in Fig 3 and 4: at 10 slpm air flow rate, it takes about 6-7 minutes to completely fill the reaction chamber of ~2,500 in³ volume (18”x12”x12” sealed box). After 7 minutes of residence in this chamber, with misting turned on, we see complete inactivation of *E.coli* on the surface of the tomatoes. Similar results were obtained with spinach leaves and with use of *E.faecalis* bacteria.

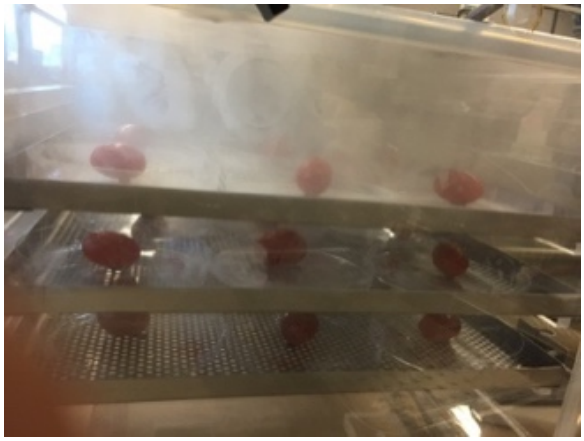

Fig 3. Photograph of cherry tomatoes being treated by the plasma-generated mist

Gliding Arc Plasmatron flow-through system

In many cases, treatment of fresh produce, at the factory, is accomplished by washing large volumes of produce in water, frequently containing disinfectant solution, such as bleach or peracetic acid, etc. Here we have designed a plasma treatment system for flowing water. Dielectric Barrier Discharge is not suitable for this application due to low volume of the water we are able to treat, at atmospheric air conditions. For this reason we have increased the power of the plasma system and utilized the gliding arc plasmatron setup, similar to the one previously described by the authors. Due to excessive heat generated in this quasi-thermal plasma, active cooling of the electrodes and the post-plasma zone is required.

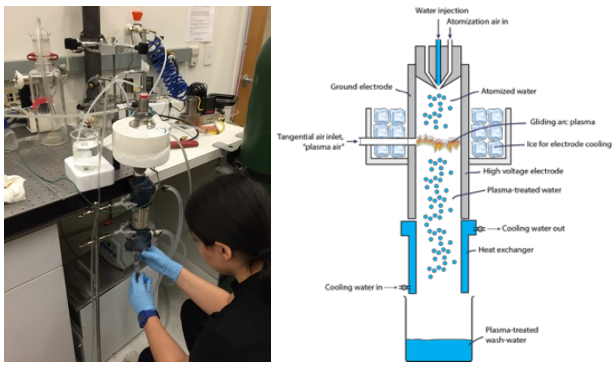

Fig. 5. Photograph and schematic of the gliding arc plasmatron treatment setup

The treatment conditions were as follows: compressed air at 60 slpm through the plasmatron, 10 ml/min tap water, electrode cooling with dry ice and post-plasma cooling with chilled water at +2 ºC. The 10 ml of plasma-treated water was immediately mixed with 1 ml of PBS containing 10^7 cfu of *E.coli* O:157 H7, mixed for 10 minutes, and 1 ml plated for incubation overnight. The results show complete inactivation of *E.coli* in water by plasma-treated water.