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Physico-chemical evaluation of surface dielectric barrier discharge (SDBD) plasma technology for inactivation and removal of *Aspergillus flavus* spores in packaged pistachios

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Abstract

Surface dielectric barrier discharge (SDBD) plasma is a novel non-thermal technology capable of generating reactive oxygen and nitrogen species at atmospheric pressure without the need for noble gases in food packaging. In this study, pistachio kernel samples contaminated with *Aspergillus flavus* spores were treated with SDBD plasma at a voltage of 6.8 kV and a frequency of 7.4 kHz for 10, 20, and 30 min using air as the working gas inside the packaging. The reduction in microbial load and the physical characteristics of the plasma, including the current-voltage characteristics, were investigated, and the plasma power was calculated. Optical emission spectroscopy (OES) was used to identify the active species generated in the plasma. In addition, ozone and reactive nitrogen species (NO_x) production was measured, and changes in surface morphology (FESEM), weight loss, and sensory and color parameters were evaluated. OES analysis confirmed the presence of reactive species, including excited nitrogen (*N₂), hydroxyl radicals (•OH), and atomic oxygen (O). Treatment for 30 min resulted in a 4-log reduction (99 %) in the population of *A. flavus* spores. FESEM images showed complete destruction of the spore cell wall and depletion of the spore cytoplasm after 30 min of treatment. Sensory evaluation using a 9-point hedonic scale showed that treatment for up to 10 min had no adverse effect on the sensory properties of pistachio kernels. However, increasing the treatment time to 20 and 30 min, while maintaining the odor and taste of the product, resulted in a significant decrease in color scores. With its effective sterilization capability, low cost, and preservation of sensory quality at shorter treatment times, SDBD technology represents a promising method for enhancing the safety and shelf life of pistachios and other agricultural products.

Keywords: Non-thermal plasma, surface dielectric barrier discharge (SDBD), *Aspergillus flavus*, plasma sterilization, pistachio kernels

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