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Coop Research Program

Non-thermal plasma as a sustainable intervention technology to improve shelf life and safety of sprouted seeds

Final project fact sheet

The project investigated the potential of non-thermal atmospheric pressure plasma as a novel approach for disinfection of sprout seeds in order to reduce food loss and increase food safety in sprout production. The results of plasma treatment experiments demonstrated the highly efficient reduction of microorganisms on seeds, while preserving their germination properties at moderate treatment times. Prolonged treatment times resulted in higher temperature, which negatively affect the germination capacity of seeds. In conclusion, cold atmospheric pressure plasma (CAPP) shows potential as a sustainable decontamination technology in the production process of sprouts, which can contribute to food safety and improved shelf life of the product.

Motivation

The consumption of fresh fruit and vegetable products has dramatically increased during the past few decades and substantially contributes to consumers' health. However, these minimally-processed foods are characterized by a short shelf life which causes up to 20-30% of product losses per year, and by the risk of foodborne pathogens. The current lack of effective and sustainable seed disinfection technologies demonstrates the need for research of relevant decontamination methods in sprout production to improve food safety and prolonged shelf life. Non-thermal plasma, a partly ionized gas applied at <100°C, represents a novel and sustainable disinfection technology able to inactivate microorganisms without using hazardous chemicals.

Objective

The major goal of this project was to evaluate CAPP as a novel intervention technique able to improve the quality and safety of sprout food products. The study focused on three different CAPP treatment systems: an atmospheric pressure volumetric Dielectric Barrier Discharge (DBD), a Plasma Circulating Fluidized Bed Reactor (PCFBR) and a commercially available Diffuse Coplanar Surface Barrier Discharge (DCSBD) system. The aim was to evaluate their applicability for decontamination of seeds and to examine the role of different parameters such as microbial contamination, substrate surface properties, moisture content and variations in the power input. The study also investigated the impact of CAPP treatment on seedling and sprout attributes.

Research Highlights

For seeds treated in the PCFBR, no significant reduction in microbial rates were observed. This was probably due to short exposure times, insufficient for the effective inactivation of microorganisms. More significant results were obtained with DBD and DCSBD systems. The inactivation efficiency was higher for artificially applied *E. coli* compared to native microbiota in cress seeds and alfa alfa seeds. However, the reduction of native microbiota revealed a similar kinetics and increase with treatment time. The study showed that complex surface topology of seeds reduced CAPP efficiency, since rough surface can shield microorganisms. However, it was possible to improve inactivation efficiency by increasing the production of reactive species and by optimizing substrate characteristics. Results also found that higher temperature resulting from prolonged treatment times considerably reduces the germination capacity. Even though treatment times up to 60 seconds had a positive effect on the germination capacity in the DCSBD system, after 120 s germination was reduced to 90% and after 180s to 42%. After 240 s of CAPP exposure, only 5% of the seeds showed germination.

The investigation of the impact of CAPP treatment on quality

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properties of seeds and sprouts revealed that treatment ≤ 120 s resulted in longer root length and shoot length compared to the control. However, the root and stem length were shorter after ≥ 180 s plasma treatment. A slight discrepancy in color was observed in the stem tissue. In particular, the leaves of plasma treated seedlings were lighter in color compared to the control. The absence of obvious defects in 10-day-old lentil seedlings indicated that CAPP treatment had no detrimental effect on the seedling morphology.

The study also investigated plasma treatment efficiency to inactivate spores from *Aspergillus niger* and *Penicillium decumbens* on seeds in the DCSBD system. Results found a maximum logarithmic reduction of spores on lentil seeds after 10 min treatment time. Yields of sprouts produced from CAPP-treated lentils seeds were even higher compared to untreated control seeds and sprouts had good organoleptic properties, appearance and shelf life.

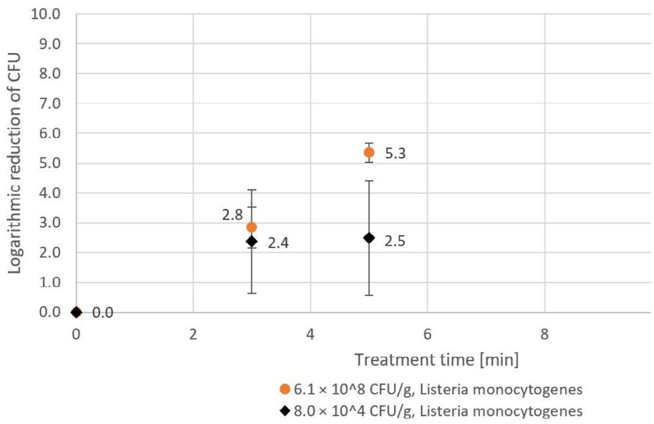

Figure 1. Effect of CAPP treatment of Listeria monocytogenes on lentil seeds. Inoculation was performed either as high initial inoculation (6.1 108 CFU/g) or low initial inoculation (8.0 104 CFU/g) prior to treatment of seeds for 3, 5, or 10 min in the DCSBD. Source: Waskow et al. (2018).

Relevance to Stakeholders

The study investigated the potential of CAPP as a novel technology to reduce food loss and increase the quality and safety of sprout food products. Results revealed the influence of different parameters on treatment efficiency and allowed the indentification of major challenges of this approach. For example, a technological development of measures able to prevent overheating of seeds during plasma treatment was found to be fundamental to preserve optimal germination capacity. Another important prerequisite for the implementation of CAPP treatment on an industrial scale is the construction of systems that guarantee uniform plasma treatment of seeds.

Selected Publications

Butscher, D.; Van Loon, H.; Waskow, A.; von Rohr, P.R. and Schuppler, M. Plasma inactivation of microorganisms on sprout seeds in a dielectric barrier discharge. ***Int. J. Food Microbiol***. **2016**. 238, pp.222-232.

Waskow, A.; Betschart, J.; Butscher, D.; Oberbossel, G.; Klöti, D.; Büttner-Mainik , A.; Adamcik, J.; Rudolf von Rohr, P.; Schuppler, M. Characterization of efficiency and mechanisms of cold atmospheric pressure plasma decontamination of seeds for sprout production. ***Front. Microbiol***. **2018**. 9:3164.

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https://worldfoodsystem.ethz.ch/research/research-programs/CRP/microPLASMA.html

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