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INNOVATIONS IN DESCONTAMINATION OF SURFACES IN CONTACT WITH PORK FRESH MEAT: USE OF PLASMA ACTIVATED WATER AND UV-C RADIATION

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I. INTRODUCTION

Currently, food safety is one of the main objectives of the food industry. Therefore, there is a search for technologies capable of reducing the microbial load present in surfaces in contact of fresh meat (equipment, utensils, etc.) without affecting the quality of the food product. As a result, emerging non-thermal technologies have been developed as an alternative to traditional technologies. Among these emerging technologies are Ultraviolet-C light (UV-C), high-frequency ultrasound, and cold atmospheric plasma [1].

UV-C light (200–280 nm) is a type of ultraviolet light (100–400 nm) used for sterilizing liquids, air, and surfaces. It is a non-thermal technology that employs short-wavelength energy to inactivate microorganisms, as in the range of 250 to 260 nm it causes damage to microbial cells [2]. This process is based on the production of photoproducts (pyrimidine, pyrimidone 6-4) and pyrimidine dimers, which damage microbial DNA and cellular proteins, leading to the alteration of DNA transcription and replication.

Plasma-activated water (PAW) is water that has been treated with cold plasma to modify its chemical and biological properties. This process introduces reactive oxygen and nitrogen species (ROS and RNS) into the water, such as hydrogen peroxide (H_2O_2), nitrates (NO_3^-), nitrites (NO_2^-), and free radicals. These species give the water antimicrobial, antioxidant, and biostimulant properties [3].

Due to its high diversity of reactive oxygen and nitrogen species, PAW presents great potential for application in the food industry to improve the microbiological quality of food, decontaminate contact surfaces, and achieve the characteristic attributes of cured meat products without the need to add nitrites.

II. MATERIALS AND METHODS

A piece of conveyor belt from a fresh meat processing industry was used, which was previously soiled to simulate conditions similar to those found during the production process. It was divided into 8 × 10 cm sections for each sampling point. Each condition was replicated three times. To evaluate the antimicrobial effect of UV-C light, a strain of *L. monocytogenes* was used, while for PAW, three microorganisms were studied: *L. monocytogenes*, *Salmonella* spp., and *Escherichia coli* O157:H7. The belt was inoculated with 100 µL of each strain and left for 15 minutes at room temperature under sterile conditions to allow the microorganisms to adhere to the surface.

For the decontamination study using UV-C light, a UV-C lamp was used. The lamp's intensity was measured with a radiometer (model VLX3W; sensor VLX254; Vilber Louf). An application distance of 10 cm was studied, along with three exposure times: 10, 20, and 30 seconds. The UV-C light dose was calculated based on the exposure time and lamp intensity.

PAW was applied to the previously inoculated surface at a dose of 6 mL. To assess its antimicrobial effect, two treatment conditions were studied: immediate application (treatment 1) and after 10 minutes (treatment 2).

The experimental data were analyzed using the Statgraphics program (version 5.1 Plus, Statgraphics Technologies; Virginia, United States). The mean values were subjected to the Least Significant Difference (LSD) test with $p<0.05$. The data represented in the graphs and figures are expressed as the mean ± standard deviation (SD).

III. RESULTS AND DISCUSSION

In the case of the control, *Salmonella* spp. showed a microbial count of 2 log CFU/cm² on the surface, *L. monocytogenes* ranged between 3–4 log CFU/cm², and *E. coli* STEC had a count of 1.5 log CFU/cm². This indicates that the inoculation was effective and that, without treatment, the microorganisms can survive on the surface of the conveyor belt. Table 1 presents the results obtained after applying different doses of UV-C light to the conveyor belt.

Table 1. Reduction or increase (as % log CFU/cm²) in *L. monocytogenes* counts on the surface of the conveyor belt after UV-C light application at a distance of 10 cm.

Dose (kJ/m²)	Aplication time (s)	Distance (cm)	Average	Deviation	Reduction (% log UFC/cm²)
0	-	-	3.00[a]	0.03	0% (3,0 log UFC/cm²)
1.56	10	10	0.60[ab]	0.00	-80%
3.12	20	10	0.34[b]	0.00	-89%
4.67	30	10	0.00[b]	0.00	-100%

According to the results obtained, we can confirm that there is a direct relationship between the UV-C light dose and the reduction of bacterial load. Increasing the dose enhances effectiveness, achieving complete elimination at 4.67 kJ/m². In the case of the lowest dose, complete reduction is not achieved, but the results are still quite good.

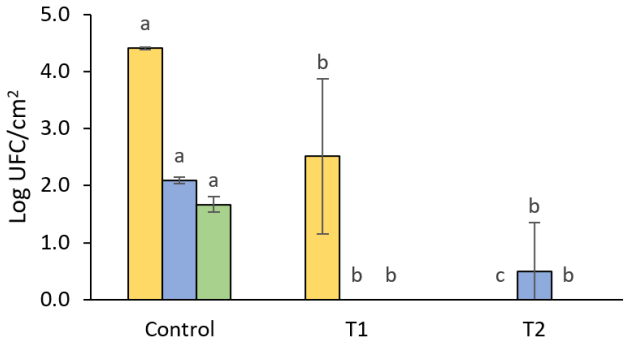


Figure 1. Counts (in log UFC/cm²) obtained on the surface of the conveyor belt of: ■ *L. monocytogenes*; ■ *Escherichia coli* y ■ *Salmonella spp.* after application of plasma-activated water (PAW). Different lowercase letters represent significant differences ($p<0.05$) between treatments for each pathogenic microorganism.

Regarding the results obtained after the application of PAW (figure 1), a significant reduction in bacterial load was observed. All pathogens showed a reduction of up to 100% after PAW treatment compared to the control. *L. monocytogenes* initially exhibited a much higher microbial load, but in treatment 2, a complete reduction was achieved.

IV. CONCLUSION

Both UV-C light and PAW are viable emerging technologies for improving food safety in the meat industry. Their application can significantly contribute to reducing pathogenic microorganisms on equipment surfaces in contact with fresh meat, minimizing contamination risks, and enhancing the microbiological quality of the final product. Further research under different study conditions is required to confirm these results.

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