IN-PACKAGE COLD PLASMA TREATMENT OF RAW MEAT

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Abstract – The effects of in-package cold plasma (IP-CP) treatments on the safety and quality of fresh meat were evaluated using chicken breast meat (*pectoralis major*) as a model. Raw breast meat was packed in trays, treated at 70 kV for different times (0, 60, 180, or 300 sec), and stored at 4°C for 5 days. *Campylobacter, Salmonella*, psychrophiles, and CIE L*a*b* were measured before and after the IP-CP treatments. Populations of foodborne pathogens *Campylobacter* and *Salmonella* were significantly lower and psychrophile growth was inhibited after IP-CP treatments. There were no pre- and post-treatment differences in L*a*b* values on the meat surface. Results indicate that IP-CP can reduce meat spoilage and foodborne pathogen risks without negatively impacting meat appearance.

Key Words – *Campylobacter*, poultry, psychrophiles, *Salmonella*.

I. INTRODUCTION

Microbiological quality and safety of raw meat have been a challenge for industry. Each year, millions of pounds of fresh poultry meat products are lost as a result of microbiological spoilage in the US (1). In 2011, a potential *Salmonella* contamination resulted in a recall of 36 million pounds of ground turkey (2). In-package cold plasma (IP-CP) treatment is a novel and effective non-thermal antimicrobial technique for inactivating foodborne pathogens and extending shelf life in fresh foods. Misra et al. (3) treated fresh strawberries with the IP-CP and reported a 2 log reduction in background microflora (aerobic mesophilic bacteria, yeast, and mold) within 24 h post-treatment without significant effects on product color and firmness. Ziuzina et al. (4) and Misra et al (5) treated cherry tomatoes with IP-CP and found that treatments for 10, 60 or 120 sec resulted in 3.1 to 6.7 log reductions in *Salmonella*, *E.* coli, and *L.* monocytogenes populations without influencing product weight loss, pH, or firmness after storage. The goal of this study was to evaluate the effects of IP-CP treatments on foodborne pathogens, natural spoilage bacteria, and appearance of packaged fresh meat using raw chicken breast meat (*pectoralis major*) as a model.

II. MATERIALS AND METHODS

Fresh chicken breast fillets (*pectoralis major*) were collected from a local broiler processing plant and packed in air in a Cryovac CS977 polymeric tray. Each sealed tray contained two fillets (93.5 ± 2.5 g each) and two breast meat cylinders (2.5-cm diameter). One fillet was used to measure natural spoilage microbes (psychrophiles) and the other for surface (dorsal/bone side) color measurements. One cylinder was inoculated with a *Salmonella* suspension and the other with a *Campylobacter* suspension (~10^7 CFU/mL). Samples were treated with the IP-CP at 70 kV for 0 (control), 60, 180, or 300 sec and stored at 4°C for 5 days prior to microbiological and color analysis. *Campylobacter*, *Salmonella*, and psychrophiles were recovered and cultured via standard methods (6, 7) and surface color (CIELAB L*a*b*) was measured with a Minolta CM-700d spectrophotometer before and after the IP-CP treatment and storage. Data were analyzed using the PROC GLM procedure of SAS version 9.4. Significant differences ($p < 0.05$) between means were identified using the Tukey's means separation method.

III. RESULTS AND DISCUSSION

There were significant differences ($p < 0.05$) in microbial counts between untreated control (0 sec) and IP-CP treated raw meat samples after treatments and storage regardless of treatment time and bacterial type (Table 1). There were no differences ($p > 0.05$) in *Campylobacter* and *Salmonella* counts between 60, 180, and 300 sec treatments; however, increasing treatment time from 60 sec to more than 180 sec resulted in further inhibition ($p < 0.05$) of psychrophilic growth. Similar results were also reported with CP treated bresaola (8) and bacon (9) meat products and fresh produce (3, 4). The antimicrobial effects were likely due to the IP-CP treatment induced formation of ozone in the sealed packages (4). In the present study, we also found that significant amount of ozone (1850 – 2650 ppm) was formed in raw meat packages immediately after IP-CP treatments (data not shown). Our data demonstrate that IP-CP can inactivate both foodborne pathogens and natural spoilage bacteria on packaged raw meat surfaces.

Table 1 Effect of in-package cold plasma treatments (70 kV) on microbial counts (log CFU/mL) of raw chicken meat*

Treatment	Psychrophile	*Campylobacter*	*Salmonella*
0 sec (control)	8.33±0.07a	4.81±0.17a	5.14±0.16a
60 sec	7.81±0.03b	4.29±0.13b	4.79±0.20b
180 sec	7.19±0.12c	4.08±0.12b	4.80±0.24b
300 sec	7.33±0.15c	4.15±0.13b	4.65±0.25b

*Samples were treated at 70 kV for different times and stored at 4°C for 5 days before analyses. a-d Means within a column with no common letter differ significantly ($p < 0.05$).

There were no significant differences ($p > 0.05$) in surface L*a*b* values between pre-treated and post-treated and stored raw meat regardless of treatment time (Table 2). Previously published data (9, 10) showed no significant color changes in bacon and pork skins after they were treated with CP.

Table 2 Effect of in-package cold plasma treatments (70 kV) on CIELAB L*a*b* values of raw chicken meat surface

| Treatment | L* | | a* | | b* | |
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
0 sec (control)	55.4c	56.8bc	0.90	- 0.03	10.2	10.5
60 sec	54.8c	57.2bc	- 0.13	- 0.33	9.1	8.9
180 sec	59.5ab	62.3a	- 0.84	- 0.58	9.2	10.9
300 sec	56.4bc	59.9ab	- 0.87	- 0.69	8.0	8.8

L*a*b* values for pre-treatment were measured before packaging. L*a*b* values for post-treatment were measured after samples were treated at 70 kV for different times and stored at 4°C for 5 days. a-c Means within a color parameter with no common letter differ significantly ($p < 0.05$).

IV.   CONCLUSION

Our data demonstrate that IP-CP can significantly reduce meat spoilage and foodborne pathogen risks without negatively impacting meat appearance. For foodborne pathogens on meat surfaces, increasing treatment time beyond 60 sec does not further enhance IP-CP antimicrobial inactivation efficacy at 70 kV; however, increasing treatment time of IP-CP from 60 sec to 180 sec can further inhibit psychrophilic growth. The IP-CP at 70 kV does not significantly affect the color of the meat surface regardless of treatment time. The results also suggest that IP-CP technique can be used as one hurdle method to treat raw meat after packaging to further improve microbiological shelf life and safety.

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