IN SITU EVALUATION OF THE CONVEYOR BELT DISINFECTION SYSTEM STERILAIR® 2011-30 MODEL T/D IN INDUSTRIAL CONDITIONS

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In food processing facilities, microorganisms including *L. monocytogenes* are found in all niches (floors, walls, and drains) and on equipment such as conveyor belts, slicing and packing machines. The complex structure of processing machines makes cleaning difficult and elimination of persistent microorganism from such machines often requires harsh cleaning procedures or reconstruction of the processing line. Some conveyor belts are impossible to dismantle for cleaning so effective cleaning and disinfection methods should be developed for daily use on existing industrial equipment in food processing plants.

The antimicrobial activity of short-wave ultraviolet (UV) light in the "C" band (200 to 280 nm) is well known and has been used to reduce microbial contamination in hospitals, pharmaceutical/medical industry, water treatment plants and on food products.

UV-C light does not contain or produce toxic compounds, it does not have legal restrictions or require extensive safety equipment to utilize and these characteristics make it an interesting disinfection principle for food processing.

UV-C treatment may be used as supplemental surface disinfection after chemical disinfection of all surfaces in a food production plant and when the plant is not in use or for on-line disinfection during production using specific equipment such as a conveyor belt.

Systematic assessment of the effect of UV-C light on conveyor belts in industrial trials has not been reported. The purpose of this study was to determine the bactericidal effect of UV-C light (wavelength 254 nm) on conveyor belt surfaces in the deboning room of a high throughput meat producing plant during its regular operation.

MATERIALS AND METHODS

Sampling conditions

One hundred environmental samples were collected in the deboning room during the regular operation of the meat processing plant. Samples were swab-surface samples collected from UV-C exposed and non-exposed areas of the conveyor belt surface. Samples were collected in three different days, on day 1 a pilot study was performed to

adjust the experimental conditions to the plant operation, on days 2 and 3 samples were collected over a period of at least seven hours.

The UV-C germicidal emitting lamps (254 nm), sterilAir® 2011-30 model T/D, (sterilAir AG Oberfeldstrasse 6 CH-8570 Weinfelden) was placed underneath the meat conveyor belt INTRALOX 850 (Asuan S.A. Montevideo, Uruguay) with a distance of less than 5 cm from the surface. For the purpose of this study half of the UV-C emitting system was covered with a stainless steel plaque in order to have exposed only half of the belt surface (Fig. 1). The conveyor belt was 60 m length running at 3.3 m/min. In order to avoid sampling consecutively at the same spot samples were collected every 20 min being time zero (0 min) the collection time of the first samples (right before the start of the deboning process). Sampling areas were of 900 cm^2 delimited by a frame specially designed to define the areas with and without UV-C exposure (Fig. 1).

Fig. 1. A) Position of the UV-C germicidal emitting lamps. B) Picture shows the areas directly exposed and non-exposed to the UV-C light. C, D) Frame and sampling place along the production line.

Sample processing

Samples were swabbed by sterile sponges by two persons that alternated between UV-C exposed and non-exposed area to avoid any bias in the sampling process. The sponges were manually massaged with 10 ml Butterfield buffer stomacher for 30 seconds and then appropriate dilutions were plated. Serial dilutions were aseptically prepared and spread plated onto various selective and differential media using Petrifilm (3M Microbiology, St. Paul, Minn.). The samples were analyzed for the presence of *Listeria*, *E. coli*. as well as for total aerobic organisms and coliform bacteria. All plates were incubated under aerobic conditions.

Enumeration of bacteria.

One milliliter of the appropriate dilution for each sample was plated onto Petrifilm (3M Microbiology, St. Paul, Minn.) aerobic count plates for total aerobic organisms (APC), Petrifilm *E. coli*/coliform count plates for *E. coli* (EC) and coliform bacteria (CB), and Petrifilm™ Environmental *Listeria* Plate for *Listeria spp.* (Lis). Petrifilm plates were incubated according to the manufacturer's recommendations, and colonies were counted manually and expressed as UFC/cm^2 for APC, UFC/100cm^2 for CB and EC and for Lis. Results were log transformed for analysis and the mean logs for the treatments were compared using SPSS IBM software. CB, EC, and Lis plates with less than 10 CFU/ 100 cm^2 were not used for determination of mean log CFU per 100 cm^2.

RESULTS

Pilot study

The results of the pilot study performed on day 1, showed that during the first hour total aerobic bacterial counts values had a large dispersion. After that period of time values had a different behavior, while non UV-C exposed sampled areas have a tendency to increase over time, UV-C exposed sampled areas appeared to have a constant bacterial count value (Fig. 2). The mean log CFU per cm^2 was 2.4 ± 0.5 for non UV-C exposed areas and 1.0 ± 0.4 for the exposed ones.

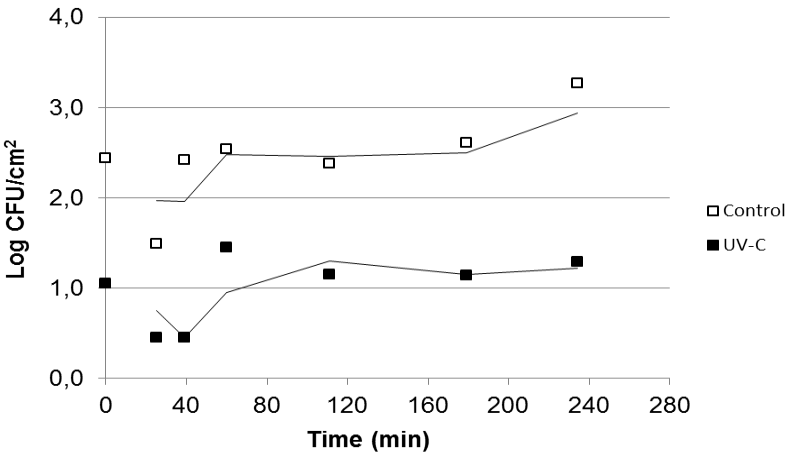

Fig. 2. Effect of UV-C irradiation on the APC expressed as Log (CFU/cm^2) over time. Control, non UV-C exposed

samples; UV-C, exposed samples.

Table 1 shows the values obtained for plate counts of EC, CB and Lis. For EC and CB the increase in counts was observed after the 3rd hour. *Listeria spp.* was tested only at time 180 min, while the sample from the non-exposed area tested positive for *Listeria spp.*, no colonies were observed on the plate for the UV-C exposed side of the conveyor belt.

Table 1.

	Bacterial count (log CFU / 100 cm^2)					
	CB*		EC*		Lis*	
Time (min)	Control	UV-C	Control	UV-C	Control	UV-C
0	1.7	0	0	0	nd	nd
20	1.6	0	0	0	nd	nd
40	2.2	0	2.1	0	nd	nd
60	1.9	0	1.7	0	nd	nd
120	2.6	<1	1.4	0	nd	nd
180	2.3	<1	<1	0	<1	0
240	3.8	2.2	3.1	1.0	nd	nd

* <1 indicates plates with visible colonies but less than 10 CFU/100 cm^2. For plates with no visible colonies a value of 0 was assigned. nd, not sampled.

The results obtained from the pilot study showed a decrease in bacterial counts due to UV-C irradiation. In addition we were able to validate the experimental design, to decide the appropriate dilutions for each microorganism and to establish the requirement to collect samples for a longer period of time.

Effect of UV-C irradiation on bacterial indicators of contamination.

Populations of aerobic bacteria, CB and EC (Table 2) revealed that samples from UV-C exposed areas had the lowest concentrations of each indicator organism. The bactericidal effect of UV-C was observed on samples collected on both days (day 2 and day 3).

The APCs log CFU/cm^2 (Fig. 3) were different ($P < 0.01$) between treatments, non UV-C exposed samples had the highest mean APC (4.1 log CFU/cm^2 for day 2 and 4.3 log

CFU/cm^2 for day 3), and UV-C exposed had a mean of 2.5 log CFU/cm^2 for both days. For the mean log CFU/cm^2 determination samples collected at time 0, 19 and 20 min were not considered.

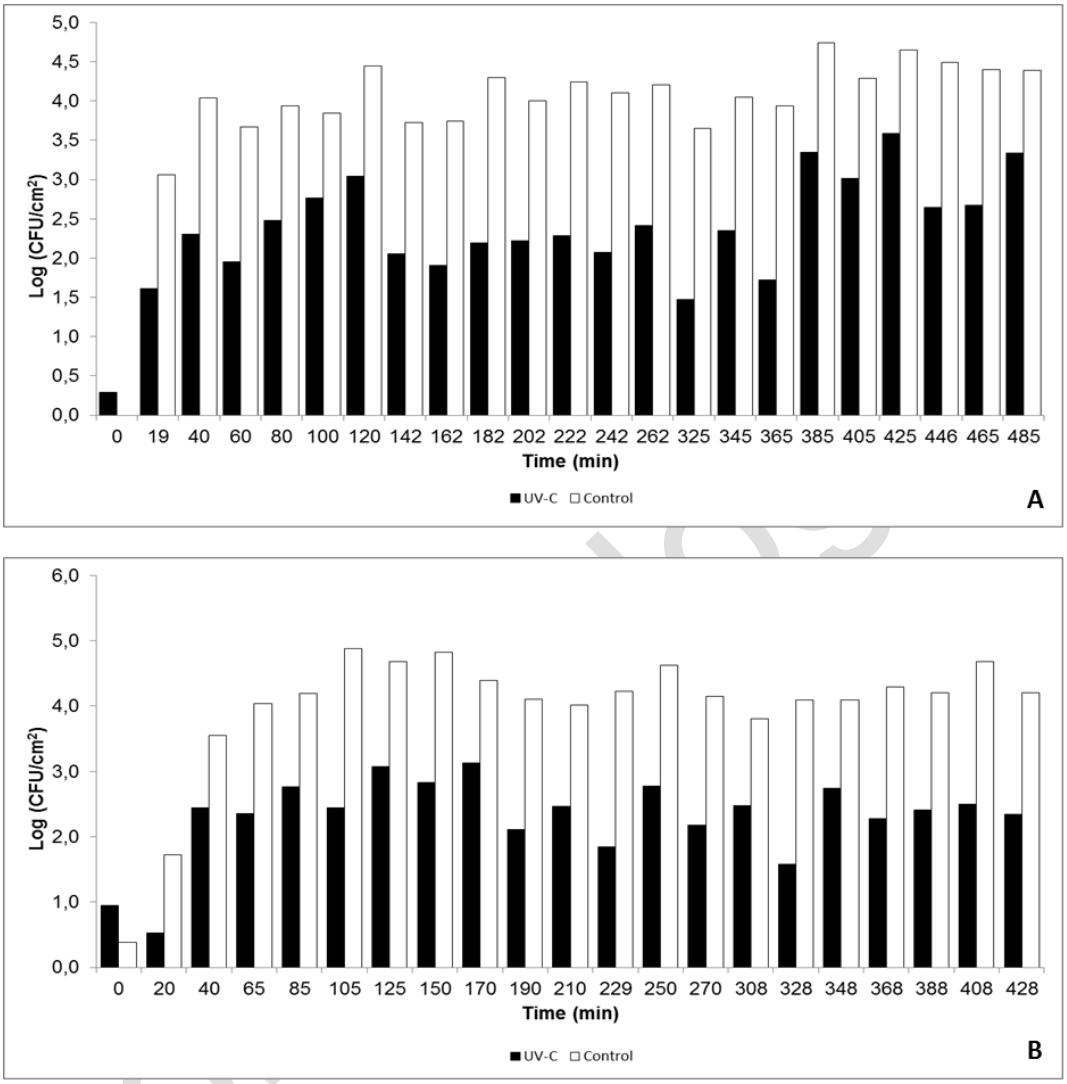

Fig. 3. Effect of UV-C irradiation on the APC expressed as Log (CFU/cm^2) over time. A, samples collected on day 2; B samples collected on day 3. Control, non UV-C exposed samples; UV-C, UV-C exposed samples.

The CB and EC results were similar in pattern to those for APC but with a lower count of colonies, in order to visualize better the results and to compare between treatments the number of colonies were expressed as Log CFU/ 100 cm^2 (Fig. 4 shows the data for CB).The mean Log CFU/ 100 cm^2 for CB and CF are shown in Table 2, mean CB and EB concentration were significantly (P 0.01) higher for the non UV-C exposed areas than for the UV-C exposed.

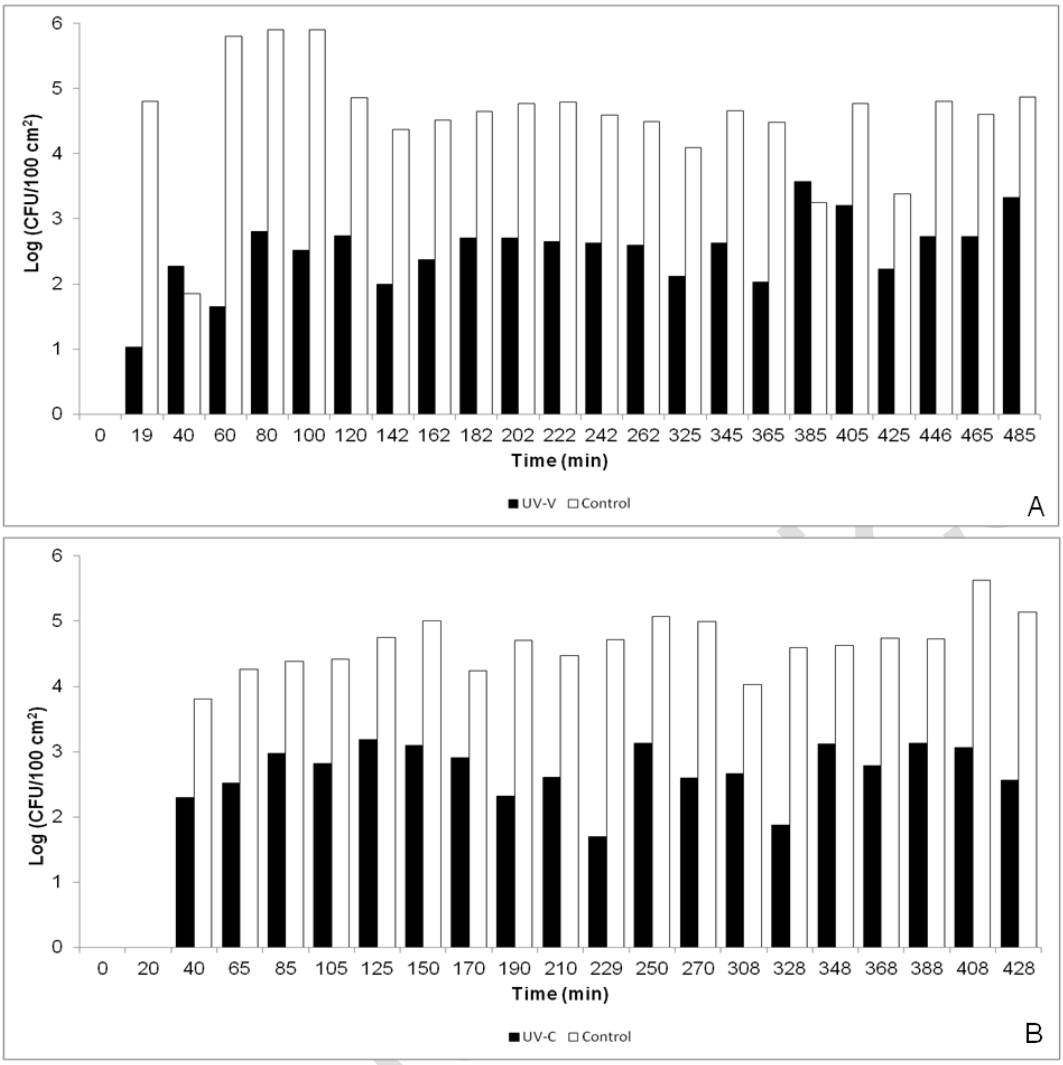

Fig. 4. Effect of UV-C irradiation on coliform bacteria CB expressed as Log (CFU/100 cm^2) over time. A, samples collected on day 2; B samples collected on day 3. Control, non UV-C exposed samples; UV-C, UV-C exposed samples.

Table 2.

	Mean CB and EC for each day (Log CFU/ 100 cm^2)							
	CB*				**EC***			
Day	Control	UV-C	Mean log reduction	Nº of samples	Control	UV-C	Mean log reduction	Nº of samples
2	4.6a	2.5b	2.1	23	3.8a	2.1b	1.7	23
3	4.7a	2.7b	2.0	21	4.4a	2.5b	1.9	21

a,b mean values within a row for the same microorganism followed by a different letter are significantly different (P 0.05). Control, non UV-C exposed samples; UV-C, UV-C exposed samples.

Samples for *Listeria spp.* were plated every hour. As a result of the lower prevalence of Listeria, compared to the other microorganism indicators of contaminations tested in this study, some of the samples were below the limit of detection of 10 CFU/ 100 cm^2. These samples were not considered for statistical assay. In these conditions it was observed a reduction due to UV-C exposure in the mean log CFU/ 100 cm^2 of 0.7 and 1.7 for day 2 and 3 respectively (Table 3).

Table 3.

	Listeria (Log CFU/ 100 cm^2)					
	UV-C			**Control**		
Day	Nº of samples	Nº(%) of samples above LOD[c]	Mean log CFU/ 100 cm^2	Nº(%) of samples above LOD	Mean log CFU/ 100 cm^2	Mean log reduction
2	7	4 (57)	1.2a	7 (100)	1.9b	0.7
3	10	3 (30)	1.3a	10 (100)	3.0b	1.7

a,b mean values within a row followed by a different letter are significantly different (P 0.05). Control, non UV-C exposed samples; UV-C, UV-C exposed samples. [c] Number of samples for which plate counts were above the limit of detection (LOD) of the 10 CFU/ 100 cm^2.

Table 4 summarizes the effect of using the UV-C irradiation system. A reduction in bacterial counts is observed for the microorganism tested.

Table 4.

	UV-C irradiation reduction in bacterial counts (%)*
Total aerobic (APC)	97
E. coli (EC)	98
Coliform bacteria (CB)	99
Listeria spp. (Lis)	94

CONCLUSION

This study clearly indicates that UV-C irradiation decreases the population of the microorganism tested on the surface of the conveyor belt used to transport meat along the deboning line in the meat processing plant. The reduction in the bacterial population was observed independently of the days of sample collection and the sampling process did not affect in any way the regular operation in the meat plant. These two aspects suggest that the UV-C bactericidal effect will be observed independently of the operating conditions of the meat plant. The UV-C system tested will add an extra hurdle for bacterial grow to the ones already used in the meat plant.