Meat and Muscle Biology™

Pulsed Ultraviolet Light Treatment of Chicken Parts

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Abstract: With increasing production and consumption of chicken, it is appropriate to investigate the functionality and effectiveness of microbial reduction interventions and the qualitative effects they have on food. The effectiveness of pulsed ultraviolet (PUV) light applied to chicken on a moving conveyor was evaluated for inactivation of *Escherichia coli* on the surface of raw boneless/skinless (B/S) chicken breasts, B/S chicken thighs, and bone-in/skin-on chicken thighs. The conveyor height (distance from the flashlamp) and speed were set to deliver total energy fluences of 5, 10, 20, and 30 J/cm^2 to the surface of the products. The product type by energy fluence interaction was significant ($P = 0.015$) for microbial reduction of *E. coli*. Exposure to PUV light for 5 and 30 J/cm^2 resulted in Log_{10} reductions of 0.29 and 1.04 for B/S breasts, 0.34 and 0.94 for B/S thighs, and 0.10 and 0.62 for bone-in/skin-on thighs, respectively. Lipid oxidation and changes in color of chicken samples were evaluated after 30 J/cm^2 of PUV light treatment. Lipid oxidation was measured at 0, 24, 48, and 120 h after the treatment. PUV light treatment did not produce significant ($P > 0.05$) changes in lipid oxidation values for each product type. International Commission on Illumination L^*, a^*, and b^* parameters were used to report lightness and color of samples before and after treatment for B/S breasts and thighs and bone-in/skin-on thighs. Color parameters were not significantly ($P > 0.05$) affected by PUV light treatments. In conclusion, this study indicates that PUV light applied to the surface of raw chicken parts on a moving conveyor is an effective surface antimicrobial treatment while inducing minimal change in quality of the product over a 5-d storage period under aerobic conditions.

Key words: chicken, pulsed ultraviolet light, *E. coli*, lipid oxidation, color
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Introduction

Raw chicken provides all of the necessary conditions needed to harbor and support the growth of spoilage and pathogenic microorganisms during refrigerated transportation and storage. The most prevalent foodborne pathogens associated with raw chicken include *Salmonella* and *Campylobacter* (Haughton et al., 2011; United States Department of Agriculture [USDA], 2012; McLeod et al., 2018). A report by the Foodborne Disease Active Surveillance Network indicated that the numbers of foodborne illness outbreaks caused by *Salmonella* and *Campylobacter* reported in the United States in 2012 were 535 and 23, respectively (Centers for Disease Control and Prevention [CDC], 2017b). Between 1988 and 1992, the CDC reported 40 foodborne illness outbreaks associated with chicken, which accounted for 1.65% of all foodborne illness outbreaks in the United States (CDC, 1996). Between 2009 and 2015, the CDC reported a total of 123 chicken-associated foodborne illness outbreaks, which accounted for 9.60% of all outbreaks in the United States (CDC, 2017a; Dewey-Mattia et al., 2018). The apparent rise in chicken-associated outbreaks emphasizes the need to identify effective interventions to reduce the presence of the pathogens on chicken.

Current intervention steps used during poultry processing for the reduction of foodborne pathogens include the application of antimicrobial solutions in the form of diluted hypochlorite or organic acid (citric acid, propionic acid, peroxyacetic acid, or

lactic acid) rinses (Bolder, 1997; Demirci and Ngadi, 2012). A review by Demirci and Ngadi (2012) reported that hypochlorite solutions reduced *Salmonella* and *Campylobacter* by 0.1 to 2.4 and 0.2 to 3.0 Log_{10} colony-forming units (CFU)/cm^2, respectively, when applied to chicken parts. Benefits of organic acids include their low cost and consumer acceptance. Killinger et al. (2010) reported greater than 2.0 Log_{10} CFU/mL reduction of aerobic plate counts and coliform levels on carcasses after treatment with 2% lactic acid in a 3-min rinse. Regardless of their antimicrobial efficacy, higher concentrations of organic acid solutions can cause surface discoloration and other quality defects (Demirci and Ngadi, 2012).

Pulsed ultraviolet (PUV) light has been investigated as another alternative microbial reduction intervention. PUV light quickly achieves germicidal effects similar to those of conventional ultraviolet (UV) light applied for an extended time. In the UV light spectrum, wavelengths between 100 and 280 nm produce a germicidal response by altering DNA structure and damaging cellular membranes (Elmnasser et al., 2007; Koutchma, 2009). However, low energy output of conventional UV limits its use for food processing (Demirci and Ngadi, 2012).

PUV light uses a xenon flashlamp to produce a spectrum of 100 to 1,100 nm, which includes conventional UV light (100 to 400 nm). PUV light is emitted in short bursts of very high energy intensity (Dunn et al., 1997; Krishnamurthy et al., 2010; Demirci and Krishnamurthy, 2011). PUV light systems can be adjusted for the number and duration of pulses, but the current literature references 3 pulses per second with each pulse lasting 360 μs as the most common application (Demirci and Ngadi, 2012).

Previous research using a lab benchtop unit demonstrated the antimicrobial effects of PUV light on the surface of raw chicken (Keklik et al., 2009; Cassar et al., 2019). Keklik et al. (2009) studied the effect of PUV light for the reduction of *Salmonella* serovar Typhimurium on the surface of boneless/skinless (B/S) chicken breast. They reported Log_{10} reductions of *Salmonella* (CFU/cm^2) ranging from 1.2 to 2.4 after a 5-s treatment at 13 cm and a 60-s treatment at 5 cm, respectively. Cassar et al. (2019) applied PUV light to inoculated lean and skin surfaces of chicken thighs for 5 and 45 s and reported 1.21 and 1.99 Log_{10} reductions for *Escherichia coli*, 1.26 and 1.97 Log_{10} reductions for *Campylobacter*, and 1.23 and 2.12 Log_{10} reductions for *Salmonella*, respectively.

For PUV light applications to be effective in commercial settings, the technology needs to be validated on a pilot system that more closely represents commercial production. In the current study, the effectiveness of PUV light for microbial reduction and its effects on quality of chicken cuts have been investigated using PUV light applied to products on a moving conveyor, representative of those used in commercial settings.

Materials and Methods

Microorganism

E. coli K12 was selected as a nonpathogenic surrogate microorganism to replace *Salmonella* and *Campylobacter*. Previous research indicates that *E. coli* K12 act similar to *Salmonella* and *Campylobacter* in different food systems (Keklik et al., 2009; Cassar et al., 2019). Cultures were acquired from the *E. coli* Reference Center at Pennsylvania State University (University Park, PA). An antibiotic-resistant strain of *E. coli* K12 was used in order to allow antibiotic suppression of the natural microflora. Nalidixic acid (Acros Organics, Geel, Belgium) and streptomycin sulfate (Thermo Fisher Scientific, Fair Lawn, NJ) were used to prepare nalidixic acid and streptomycin sulfate–resistant (NSR) *E. coli* K12 as described by Catalano and Knabel (1994). Stock culture was stored at −80°C in 20% glycerol and 80% tryptic soy broth (TSB; BD, Franklin Lakes, NJ). Working culture of *E. coli* K12 NSR was maintained at 4°C in TSB supplemented with 0.6% yeast extract and 100 mg/L each of nalidixic acid and streptomycin sulfate (TSBYE-NS) and subcultured every 14 d.

Inoculum preparation

E. coli K12 NSR inoculum was prepared as described in Cassar et al. (2019); working culture was transferred into 1,000 mL of TSBYE-NS and incubated 37°C for 24 h. After incubation, cultures were centrifuged (30 min at 3,300 × *g* and 10°C), the supernatant was removed, and 500 mL of sterile 0.1% peptone water (BD) was used to resuspend the cells. The suspension was recentrifuged under the same conditions, and the pellet was resuspended in sterile buffered peptone water (Oxoid, Hampshire, UK) with a 1× working concentration yielding a cell population of approximately 8.0 Log_{10} CFU/mL.

Chicken meat preparation and inoculation

B/S breast, B/S thigh, and bone-in/skin-on thighs were provided by a local poultry processing plant.

Chicken parts were kept frozen (ca. −17°C) until use and transferred to a refrigerator (ca. 4°C) to thaw 48 h prior to each trial. Samples were removed from the refrigerator and brought to room temperature (ca. 18°C) 2 h before each trial so as to not cold shock microbes during inoculation.

Chicken parts were inoculated with *E. coli* K12 NSR by means of total submersion (15 parts per 1,000 mL of inoculum). Chicken parts were held under submersion for 30 min at room temperature (ca. 18°C) to promote attachment, achieve even distribution, and obtain 5.0–6.0 Log_{10} CFU/cm^2 of *E. coli* K12 NSR on the surface (Firstenberg-Eden, 1981).

Pulsed ultraviolet light conveyor system

A food product conveyor (350-cm-long and 38-cm-wide stainless steel mesh belt) was equipped with 2 PUV flashlamps mounted in series above the long axis of the conveyor (Model RC-802, XENON Corporation, Wilmington, MA). The assembly included two 40.64-cm (16 in), linear "C" type xenon flashlamps, used to generate PUV light (Figure 1). The flashlamps were positioned above the conveyor with the long axis of each lamp aligned parallel to the long axis of the conveyor to deliver the greatest possible amount of PUV fluence in a short period of time. Each lamp produced 3 polychromatic (100 to 1,100 nm) flashes per second with a flash duration of 360 µs each.

PUV light treatment

Inoculated chicken parts were individually subjected to PUV light treatment using the PUV light conveyor system as described. The parts were placed on the conveyor, and conveyor speed was adjusted to obtain the desired energy fluence. Total energy delivered to the surface of the chicken parts was controlled by adjusting the speed of the conveyor (meters per second) at a fixed proximity of 10 cm below the quartz windows of the PUV light units. Conveyor speeds were adjusted to 0.131, 0.065, 0.032, and 0.022 m/s to obtain fluences of 5, 10, 20, or 30 J/cm^2, respectively. Chicken parts ($n = 6$) were treated in 2 passes with 180° top to bottom inversion of the chicken parts between passes to achieve complete PUV light exposure to all surfaces.

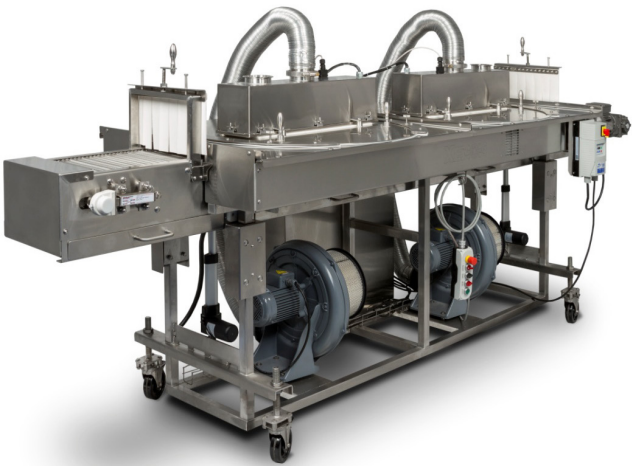

Figure 1. Image of the RC-802 Interweave Pulsed Ultraviolet System (XENON Corporation, 2017).

Microbial analysis

After treatment, 25 cm^2 were removed from each treated surface (top/bottom) of each chicken part using a scalpel, yielding a total of 50 cm^2. Surface samples were weighed to ensure that approximately 50 g was collected from each part. The surface samples were then transferred to a filtered stomacher bag (Classic 400, Seward Limited, Worthing, UK) with 100 mL of sterile buffered peptone water (Oxoid). Samples were stomached (Model 400, Seward Limited) for 1 min at 260 rpm. Solutions filtered out of the samples were serially diluted in buffered peptone water and spirally plated on TSAYE-NS plates using an autoplater (Autoplate 4000, Spiral Biotech, San Diego, CA). Cultured TSAYE-NS plates were incubated at 37°C for 24 h prior to enumeration using an autocounter (Q-Count version 2.1, Spiral Biotech). Microbial reductions (Log_{10} CFU/cm^2) were determined via comparison of treated and untreated (control) samples, all of which passed under the conveyor.

Energy and temperature measurements

Total energy (joules per square centimeter) delivered to the samples was determined using a Nova Laser Power/Energy Monitor (P/N 1J06013, Ophir Optronics Limited, Jerusalem, Israel) with a 46-mm aperture pyroelectric metallic absorber (P/N 1Z02860, Ophir Optronics Limited) to record energy at stationary 5-cm increments along the length of the conveyor belt. Energy recordings were averaged over 10 pulses and then calculated according to exposure duration to assess energy (joules per square centimeter) delivered to the sample. After plotting the total energy delivered at 5-cm increments along the length of the conveyor, total energy was calculated. To achieve total energy values of 5, 10, 20, and 30 J/cm^2, conveyor speeds were set at 0.131, 0.065, 0.032, and 0.022 m/s, respectively.

Chicken parts surface temperatures were determined using a type K thermocouple (Omegaette HH306, Omega Engineering Incorporated, Norwalk, CT) with

a 15-cm-long and 1-mm-diameter probe. The temperature probe was placed approximately 1 mm under the surface of the chicken thigh sample within no more than 3 s following treatment. The probe measurements were derived from the 1 × 1 mm sensing tip of the probe.

Lipid oxidation

Whole chicken parts ($n = 3$) were treated with 30 J/cm^2 of PUV light to observe effects on lipid oxidation, if they existed. Samples (10 g) were collected from each part and blended with 50 mL of deionized water, 5 mL of ethylenediaminetetraacetic acid, and 5 mL of n-propyl gallate for 2 min. The blended solution was transferred to a Kjeldahl flask with 2.5 mL of hydrochloride in 47.5 mL of deionized water. The solution was brought to a boil in order to collect approximately 50 mL of distillate, 5 mL of which was mixed with 5 mL of thiobarbituric acid reagent and left in a boiling water bath for 35 min. After 10 min of cooling, samples were transferred to cuvettes, and absorbance was measured using a spectrometer at 538 nm. Lipid oxidation was assessed by measuring thiobarbituric acid reactive substances (TBARS), as described by Tarladgis et al. (1960). Using this analysis, lipid oxidation was reported as the amount of malonaldehyde per 10 g of meat as calculated from a standard curve prepared as described by Tarladgis et al. (1960) and Texas Tech University (2018). Chicken part sample TBARS values were measured immediately following PUV light treatment and repeated after 24, 48, and 120 h of refrigeration (ca. 4°C) in manually sealed Ziploc plastic bags.

CIELAB color measurement

Whole chicken parts ($n = 3$) were treated with 30 J/cm^2 of PUV light to observe effects on surface color. Surface color of B/S breast, B/S thighs, and skin-on thighs were assessed using a Minolta Chroma Meter colorimeter with an 8-mm-diameter head with diffuse illumination and an observer angle of 0° (Model CR 300, Minolta Incorporated, Ramsey, NJ) to measure the International Commission on Illumination (CIE) L^*, a^*, and b^* color parameters, where L^* represents lightness of the sample and a^* and b^* are chromaticity coordinates, $-a^*$ and $+a^*$ indicate green and red color, respectively, and $-b^*$ and $+b^*$ indicate blue and yellow color, respectively. When evaluating the color of the chicken part samples, 3 random locations per part were scanned to provide average L^*, a^*, and b^* values for each chicken part. Color measurement guidelines were completed as recommended by the American Meat Science Association (2012).

Statistical analysis

SAS software (version 9.4, SAS Institute Inc., Cary, NC) was used to carry out statistical analysis. A complete randomized design was used to evaluate microbial reduction on the surface of 6 independently evaluated chicken parts after treatment by PUV light. A 2-way analysis of variance was used to establish differences by main effects, chicken part, PUV fluence, and their interaction. Microbial reduction was established by comparing untreated control samples to treated samples and calculating microbial reduction prior to statistical analysis. When analyzing lipid oxidation ($n = 3$), a repeated measures general linear model was used to evaluate chicken part type and storage time as repeated measures and their interaction after treatment by 30 J/cm^2 of PUV light. Color values ($n = 3$) were analyzed using a paired t test to evaluate changes before and after treatment for each product and each CIE L^*, a^*, and b^* color parameter. Tukey's multiple comparison test was used to separate means when the F-test was significant, $P \leq 0.05$. The standard error of the mean was provided in tables, when necessary, to represent the deviation of the means within treatments (Steel and Torrie, 1960).

Results and Discussion

Microbial reductions

The Log_{10} reduction of *E. coli* K12 NSR on the surface of B/S chicken thigh and breasts and bone-in/skin-on chicken thighs after treatment by the PUV light on a moving conveyor was assessed at energy fluence values of 5, 10, 20, and 30 J/cm² (Table 1). The product type by energy interaction for microbial reduction on chicken samples was significant ($P = 0.015$) for microbial reduction of *E. coli*. Microbial reduction increased with exposure to greater total fluence and the absence of skin on

Table 1. Microbial reductions (Log_{10} CFU/cm^2) of *Escherichia coli* K12 on the surface of chicken parts after pulsed ultraviolet light treatments

	Energy (J/cm^2)			
Product	5	10	20	30
Boneless/Skinless Breast	0.28^{AB}	0.47^{BCDE}	0.59^{EF}	1.04^{H}
Boneless/Skinless Thigh	0.34^{BCD}	0.51^{DE}	0.74^{FG}	0.94^{GH}
Bone-in/Skin-on Thigh	0.10^{A}	0.28^{AB}	0.48^{CDE}	0.62^{EF}

$^{A–H}$Means without a common superscript are significantly different ($P < 0.05$).

Standard error of the mean = 0.033.

the product surface. With the exception of B/S breast after 5 J/cm^2 of PUV light exposure, both B/S breast and thighs had significantly ($P < 0.05$) greater microbial reduction compared with bone-in/skin-on thighs at all other respective energy levels of exposure. As expected from a previous study (Cassar et al., 2019), microbial reduction on the surface of chicken parts after exposure to PUV light was significantly greater ($P < 0.05$) with increasing energy (joules per square centimeter) delivered. Nevertheless, microbial reductions throughout this study were generally less than 1.0 Log_{10}.

Microbial destruction by PUV light applied on the moving conveyor appears to be decreased when compared with previous work using a benchtop PUV light unit. The benchtop PUV light units, described in the literature, treated samples of chicken in a fixed position using duration of exposure and proximity to the PUV flashlamp to adjust for total energy exposure. Keklik et al. (2010) investigated the effect of PUV light for the reduction of *Salmonella* serovar Typhimurium on the surface of B/S chicken breast using a benchtop PUV light unit. They reported Log_{10} reductions of *Salmonella* (CFU/cm^2) ranging from 1.2 to 2.4 after a 5-s treatment at 13 cm (5.6 J/cm^2) and a 60-s treatment at 5 cm (67.0 J/cm^2), respectively. Using a similar benchtop PUV light unit, McLeod et al. (2018) subjected B/S chicken breast fillets inoculated with spoilage and pathogenic bacteria to PUV light with fluences ranging from 1.25 to 18 J/cm^2, leading to reductions ranging from 0.9 to 3.0 Log_{10} (CFU/cm^2) of *Salmonella enterica* serovar Enteritidis, *Listeria monocytogenes*, *Staphylococcus aureus*, *E. coli*, *Pseudomonas* spp., *Brochothrix thermosphacta*, and *Carnobacterium divergens*.

Although no study has yet been designed to directly compare the performance of benchtop versus conveyor-mounted PUV systems, previous work from this laboratory provides pertinent insight. Using a benchtop PUV system delivering 20.5 J/cm^2 to lean surface of chicken thighs, Cassar et al. (2019) observed a microbial reduction of 1.70 Log_{10} for *E. coli* K12 NSR. In the current study, using PUV lights mounted above a moving conveyor, an energy fluence of 20 J/cm^2 produced a much smaller microbial reduction of 0.74 Log_{10} for *E. coli* K12 NSR on the lean surface of chicken thigh with nearly identical energy fluence. Additionally, differences in microbial reduction may be associated with PUV light shadowing due to the irregular shapes and sizes of whole chicken parts. Because PUV light is only effective when delivered directly to the microbes, shadowing would be expected to protect microorganisms from germicidal exposure. These specific observations and numerous others warrant continued investigation to better understand this discrepancy.

Temperature and energy measurement

After warming at room temperature (ca. 18°C) for 2 h, the initial surface temperature of the raw chicken thigh samples was ca. 17.8°C. The surface temperature was measured immediately following each PUV light treatment condition at 5, 10, 20, and 30 J/cm^2. Rise in temperature was not significantly different ($P > 0.05$) between skin and lean surface of raw chicken parts but did significantly increase with greater total PUV light fluence ($P < 0.0001$). The final surface temperature for chicken parts after exposure to 5, 10, 20, and 30 J/cm^2 was 19.1°C, 20.8°C, 22.9°C, and 26.9°C, respectively. The final surface temperatures were the result of 1.4°C, 3.0°C, 5.0°C, and 9.0°C increases at 5, 10, 20, and 30 J/cm^2, respectively (Table 2).

Other researchers have reported similar findings with numerically greater temperature rise in a benchtop PUV unit compared with that reported in the current study. Keklik et al. (2010) reported 3.9°C, 6.7°C, 11.5°C, and 14.1°C rise at 2.9, 8.7, 17.4, and 26.1 J/cm^2, and Cassar et al. (2019) reported 2.8°C, 4.5°C, 6.2°C, and 10.0°C rise at 3.38, 6.9, 10.2, and 20.8 J/cm^2, respectively, for chicken parts treated with PUV light in a benchtop system. PUV light studies using a benchtop unit reported temperature rise approximately twice that of the conveyor system. The apparent difference in temperature rise between the benchtop and conveyor-type PUV systems may be due to the specific designs of the 2 units. The treatment chambers of the benchtop and conveyor units create convection and reflection effects that trap the heat energy associated with PUV light spectrum. For the benchtop system, the chamber is completely enclosed, whereas the conveyor system has larger total volume below the lamps due to the width of the conveyor belt and is open to the

Table 2. Surface temperatures (°C) of chicken samples before and after pulsed ultraviolet light treatments

	Energy (J/cm^2)			
Temperature (°C)	5	10	20	30
Before	17.7	17.8	17.9	17.9
After	19.1^A	20.8^B	22.9^C	27.0^D
Change	1.4^A	3.0^B	5.0^C	9.1^D

$^{A–D}$Means within row without a common superscript are significantly different ($P < 0.05$).

Standard error of the mean = 0.630.

outside on each end. These design differences should be investigated to determine whether they contribute to variation in temperature or microbial destruction.

Lipid oxidation

Lipid oxidation was assessed for B/S breasts, B/S thighs, and bone-in/skin-on thighs after treatment of 30 J/cm^2 of PUV light. Figure 2 depicts chicken product type TBARS values as a function of PUV light treatment at 4 time points: 0, 24, 48, and 120 h. The plot suggests that there is no significant difference ($P > 0.05$) between PUV light–treated and untreated chicken parts for each respective product type over time. Regardless of product type or treatment, refrigerated storage over time significantly contributed ($P < 0.05$) to increased TBARS values for all chicken product evaluated. Ultimately, PUV light treatment of 30 J/cm^2 applied to chicken parts in this study did not lead to a significant increase ($P > 0.05$) in lipid oxidation as measured by TBARS, developing, on average, 3.33 and 3.02 µg malonaldehyde per 10 g of meat immediately after PUV exposure and 6.24 and 5.95 after 120 h of refrigerated storage for control and treated samples, respectively.

A similar study by Keklik et al. (2010) reported the effects of PUV light treatment on lipid oxidation of unpackaged chicken breast. Reported values were 5.87 and 12.43 µg of malonaldehyde per 10 g of meat after a 5-s treatment at 13 cm and a 60-s treatment at 5 cm, respectively. Untreated controls were reported to have 5.42 µg of malonaldehyde per 10 g of meat. In another study, Paskeviciute et al. (2011) treated the surface of chicken breast with high-powered pulsed light (200 to 1,100 nm with pulse duration of 112 µs) and reported 2.04 and 10.19 µg of malonaldehyde per 10 g of meat after exposure of 0 and 2.7 J/cm^2 of PUV light, respectively. In an additional study by Keklik et al. (2009), PUV light–treated unpackaged chicken frankfurters were evaluated for lipid oxidation. After a 5-s treatment at 13 cm and a 60-s treatment at 5 cm, values of 5.60 and 7.65 µg of malonaldehyde per 10 g of meat were reported, respectively, and 5.03 µg of malonaldehyde per 10 g of meat was reported for untreated frankfurters. The values in the current study are consistently lower than previously reported research, which could be attributed to differences between the PUV light benchtop units and treatment using the conveyor system. The greater temperatures reported in the benchtop systems may contribute to initiation of lipid oxidation that is not observed in treatment by the conveyor system; this idea needs to be further evaluated. Additionally, the difference in fat content of the evaluated products may explain the differences observed between chicken skin—which has the greatest concentration of lipids—and other products.

CIELAB color measurement

The color parameters L^*, a^*, and b^* were assessed for B/S breasts, B/S thighs, and bone-in/skin-on thighs immediately after treatment of 30 J/cm^2 of PUV light. L^*, a^*, and b^* values were reported before and after treatment with PUV light (data not shown). Statistically, L^*, a^*, and b^* values of the products

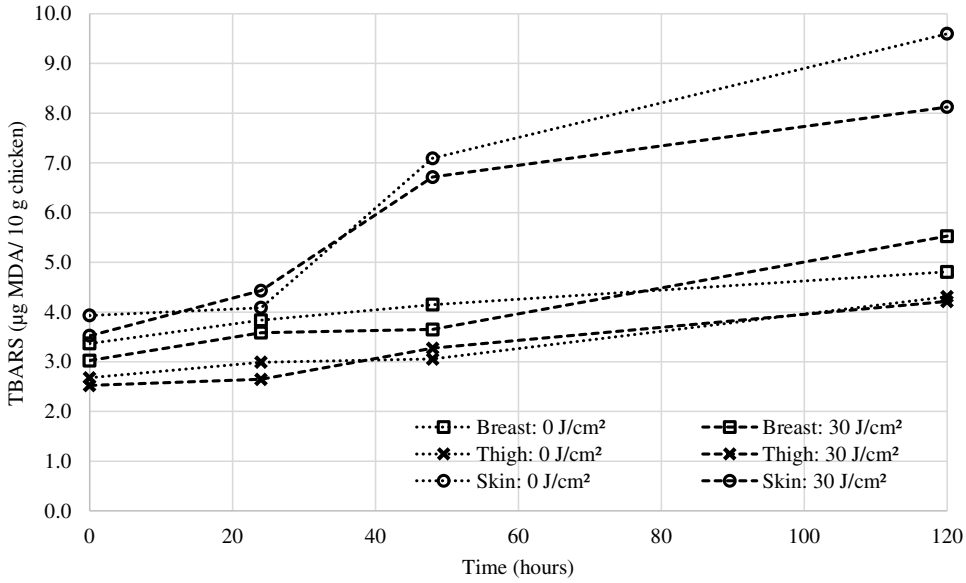

Figure 2. Thiobarbituric acid reactive substances (TBARS), as an indicator of lipid oxidation, of chicken samples 0, 24, 48, and 120 h after pulsed ultraviolet light treatments. Breast standard error of the mean (SEM) = 0.208; thigh SEM = 0.209; skin SEM = 0.476. MDA = malondialdehyde.

did not significantly ($P > 0.05$) change after treatment with 30 J/cm^2 of PUV light. In a similar study, Keklik et al. (2010) reported the fluctuations in L^*, a^*, and b^* values of B/S chicken breast after treatment with PUV light. Reported ΔL^*, Δa^*, and Δb^* values after a 5-s treatment at 13 cm (2.7 J/cm^2) were +0.59, −0.77, and +0.70, respectively ($P > 0.05$). After a 60-s treatment at 5 cm (60.2 J/cm^2), significant changes in L^*, a^*, and b^* values were reported as +23.43, +3.46, and +7.70, respectively ($P < 0.05$). The energy values in the current study did not exceed 30 J/cm^2 and did not result in any changes to surface lightness and color.

Conclusions

To the best of our knowledge, this study is the first to report the effects of PUV light applied to chicken parts on a moving conveyor. The results of this study demonstrate that PUV light treatment is effective at modestly reducing *E. coli* K12 NSR on the surface of chicken thighs, breast, and skin. The research indicates that the highest exposure of PUV light evaluated results in the greatest microbial reduction. Results for lipid oxidation and color analysis in this study indicate that PUV light, applied at 30 J/cm^2, does not have significant effects on these product quality attributes of fresh chicken parts. Furthermore, greater energy fluences resulted in greater temperature rise on the surface of the products. The increase in temperature is generally undesirable for a raw product but may lead to increased microbial reduction. Continued investigation is needed to refine the application of PUV light for microbial reduction in order to satisfy the needs of commercial poultry processors.

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