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Microbial and physicochemical quality of chicken decontaminated by UV-C light in comparison with lactic acid and sodium hypochlorite

Mikrobielle und physikalisch-chemische Qualität von mit UV-C-Licht dekontaminiertem Hühnerfleisch im Vergleich zur Dekontaminierung mit Milchsäure und Natriumhypochlorit

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Summary

The microbial contamination in chicken carcasses has become a crucial issue since excessively contaminated chicken meat would spoil quickly and might become a source of pathogenic organisms. The current study was planned to assess the efficacy of Sodium hypochlorite, lactic acid, and UV-C light decontamination techniques on microbial and physicochemical qualities of fresh raw chicken stored at refrigeration temperature (0-4oC). A total of 60 raw chicken carcasses were collected and split in two equal halves and a total of 120 split carcasses grouped in 4 groups (n=30) were treated with control ('C'), sodium hypochlorite ('SH', 50 ppm), lactic acid ('LA', 2%) and UV-C light ('UV', 415.75 mJ/cm2). The carcasses were sampled at 0, 24, 48, 72 and 96 hours of storage (0-4oC) to assess microbial, physicochemical, sensory and instrumental quality. On 96 hours of storage, TVC and *Staphylococcus* spp. count of all treatment groups remains significantly lower than 'C' group. Whereas 'LA' and 'UV' treatments were successful in reducing load of *E. coli* count. Further, 'LA' group significantly ($p<0.05$) lowered yeast and mould count at 0 hours than other groups. All groups were found to be negative for *Salmonella* spp. 'LA' group displayed significant ($p<0.05$) lower pH and sensory score, higher TBARS and POV values. Instrumental Hunter colour and Texture Profile Analysis values between treatment groups showed non-significant correlation. Sodium hypochlorite, lactic acid and UV-C light decontaminants were found to extend the shelf life of chicken up to 4 days at refrigeration storage (0–4°C), but based on microbial, physicochemical and sensory qualities, UV-C light decontamination technique was found most effective.

Keywords: Decontamination, microbial quality, physicochemical quality, shelf life, chicken

Introduction

Poultry meat is popular all around the world because of its nutritional content, ease of availability, and low cost (Chouliara et al., 2007). The world's meat consumption has been shifting towards poultry meat as the average global consumption of meat proteins over the period from 2018 to 2030 will rise by 14% (FAO-OECD, 2021). In India, 4.78 million tonnes of poultry meat are produced each year, making up about 51.44% of the nation's total meat production (BAHS, 2022). Over the previous year, the production of poultry meat increased by 6.86% and the per capita availability of meat in 2021–2022 was 6.82 kg (BAHS, 2022). India is the second-fastest expanding processed meat and poultry market worldwide with a 22% of Compound annual growth rate [CAGR] (Sowmya and Somsai, 2020).

Pathogenic microbes are found in the intestines, feathers, and skin of live chickens, which can contaminate carcasses during slaughter and processing. Despite all measures, slaughter, evisceration, and dressing activities invariably result in microbial contamination in depths and particularly on the surface of nutrient-rich meat through contact with different equipment, tools, hands, and clothing (Biswas et al., 2017).

High levels of microbial contamination in chicken carcasses have become a crucial issue since excessively contaminated chicken meat would spoil quickly and become source of pathogenic organisms (Saad et al., 2015; Duan et al., 2017; Shewail et al., 2018; Shivaji et al., 2022). The principal harmful food safety related microorganisms detected on the surface of chicken meat include *Salmonella* spp., *Escherichia coli*, and *Staphylococcus aureus* (Hecer et al., 2007; Althaus et al., 2017; Byun et al., 2021). Adequate precautions should be made to reduce food-borne pathogen contamination during the processing of chicken meat to extend shelf life (Yang et al., 2017; Philip et al., 2020).

Microbial growth constitutes the most significant component in relation to the keeping quality of fresh meat, even though meat can deteriorate in the absence of microbes (Lambert et al, 1991). The shelf life and keeping quality of meat are influenced by a number of interrelated elements, including holding temperature, ambient oxygen (O_2), endogenous enzymes, moisture (dehydration), light, and most critically, microorganisms (Biswas et al., 2007). All of these elements, alone or in combination, have the potential to cause detrimental changes in the colour, flavour, texture, and odour of meat (Faustman and Cassens, 1990; Biswas et al., 2017). The shelf life of poultry may be extended by reducing the microbial burden, which may also reflect improved food safety which provides financial advantages to processors and retailers (Burfoot and Mulvey, 2011).

Many antimicrobial substances, including bromine, chlorine dioxide, cetyl pyridium chloride, organic acids, trisodium phosphate and hypochlorous acid, are permitted for use in the processing of chicken (Bilgili, 2009; Lee et al., 2014). Chlorine is the most frequently employed of these chemicals (Izat et al., 1988; James et al., 2006), however, it has only mildly bactericidal effects on chicken carcasses and gradually loses effectiveness due to organic debris (Block, 2001; Russell and Axtell, 2005). Lactic acid was found more potent in reducing the population of microbes due to the destructive effect of lactic acid on bacteria through change in the permeability of microbial cell membranes (Morshedy and Sallam, 2009). UV-C light irradiation (UV-C) is FDA-approved and notable for its low cost, lack of production of potentially dangerous chemical residues, and minimal environmental impact (FDA, 1999; Guerrero-Beltran and Barbosa-Canovas, 2004). UV light has been shown to be a successful method for microbial inactivation by destroying bacterial DNA (Wang et al., 2005; Lim and Harrison, 2016).

Considering the above, this study aimed to investigate the effect of sodium hypochlorite, lactic acid and UV-C radiation on the microbial, physicochemical and sensory qualities of raw chicken carcasses (0–4°C).

Materials and methods

Experimental design

A total of 60 fresh raw chicken carcasses were collected from the registered slaughterhouse located at the College of Veterinary and Animal Sciences, Parbhani Maharashtra India. These carcasses were randomly distributed into four treatment groups viz., 'C', 'SH', 'LA', and 'UV' with 3 replicates of 5 carcasses in each replicate for control, sodium hypochlorite (50 ppm), lactic acid (2%) and UV-C light (415.75 mJ/cm^2), respectively. These carcasses were split into two halves and a total of 120 split carcasses with 30 split carcasses in each group were subjected to decontamination.

Decontamination of chicken carcasses

Fresh split chicken carcasses were decontaminated using sodium hypochlorite (50 ppm) dip for 10 minutes, lactic acid (2%) dip for 5 minutes and UV-C light exposure for 120 seconds at a distance of 15 cm generating energy of 415.75 mJ/cm^2 as per the method described by More et al. (2022) and stored at 0–4°C till 96 hrs. The samples from each decontaminated group were further subjected to microbial, physicochemical and sensory analysis. The half-split chicken carcasses from each group were collected at 0, 24, 48, 72, and 96 hours post-treatment for samples. The chicken thigh and drumsticks were processed for microbial and physico-chemical analysis respectively. Chicken breasts were processed for sensory and instrumental colour and texture analysis.

Microbial analysis

Chicken thigh samples were collected for microbial analysis as per the method of ISO 17604:2015. The samples were processed for estimation of Total Viable Count (TVC) and differential count of *E. coli, Staphylococcus* spp., and yeast and mould. The plating procedures employed included pouring the appropriate dilutions onto plate count agar and spreading them onto sterile Eosin Methylene Blue agar, Baired and Parker Agar and Dichloran Rose Bengal Chloramphenicol Agar as per the method of ISO 4833, 2013; ISO 16649-2:2001; ISO- 6888-1:2021; ISO 21527-1:2008, respectively. All inoculated plates were then incubated for a 24 to 48 hours at 37 °C. Values were expressed as $\log_{10}$ cfu/g. Isolation of *Salmonella* spp. was done by following three stages: pre-enrichment, enrichment and selective plating as per the method described in ISO 6579-1:2017.

Physicochemical analysis

The pH of sample was determined by the method of Association of Official Analytical Collaboration (AOAC, 1995) and pH was measured using a digital pH meter (Green Genome LMPH-10). Thiobarbituric acid-reactive substances (TBARS) value was determined according to the method described by Strange et al. (1977) with slight modification. The peroxide value (POV) was determined according to the method of Sallam et al. (2004).

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Sensory analysis

The semi-trained panellists consisting of students and staff from College of Veterinary and Animal Sciences, Parbhani carried out sensory analysis to evaluate the effect of decontaminants on the sensory attributes of raw samples. The panellists evaluated the samples for colour, odour and overall acceptability using a 9-point hedonic scale (Capita et al., 2000).

Measurement of colour

The colour of the raw chicken breasts were evaluated using a Colour Difference Meter (Spectrophotometer Colorflex EZ-45, Hunter Associates Laboratory, Inc., Reston, Virginia, USA) and hunter colour values, L* (lightness), a* (redness), and b* (yellow) were determined.

Instrumental tenderness

Texture Profile Analysis (TPA) was conducted in triplicate on each sample using a TA.XTplus Texture Analyser (Stable Micro System Ltd., UK) using an aluminum probe (P/35; 35mm DIA CYLINDER ALUMINIUM) as per the method described by González-Alonso et al. (2020) with slight modification. Hardness, springiness, cohesiveness, gumminess, and chewiness were obtained from the force-time curves.

Recording and handling of data

All the data were analyzed with Randomized Block Design using software "WASP – Web Agree Stat Package – 2.0" developed at ICAR research complex, Goa.

Results and discussion

The shelf life of chicken carcasses was assessed by microbial quality, physicochemical quality, sensory quality, and instrumental measurement of colour and texture profile analysis. Raw chicken carcasses (6 each) were sampled at 0, 24, 48, 72 and 96 hours of storage (0–4°C). The instrumental colour and tenderness were measured at 0 and 96 hours of storage (0–4°C).

Microbial analysis

Total Viable Count (TVC)

The result of mean TVC of the thigh portion of raw chicken carcasses treated by 'SH', 'LA' and 'UV' are presented in Table 1. Statistically on day 0, the TVC of 'LA' group was found to be lower than the 'C' and 'SH' groups. While it is non-significant in comparison with the 'UV' group. A similar trend was observed on 48th hour of storage. Further, TVC grew very rapidly and exceeded 6 $\log_{10}$ cfu/g by 96 hours of refrigerated storage. The TVC of 'C' group only exceeded 7 $\log_{10}$ cfu/g on 96 hours of storage. The statistical analysis revealed that the TVC of treated chicken samples was significantly lower than 'C' group but a non-significant difference was observed amongst treatment groups. Thus, based on the result of TVC, chicken samples can be stored for up to 96 hours regardless of decontaminant treatments used.

As per the process hygiene criteria total microbial limit for chilled meat is 1 x 10^6 cfu/gm and the chilled material shall be consumed within 2 to 4 days under normal refrigeration conditions of storage (FSSR, 2011). The shelf life of a decontaminated chicken in this research was extended upto 4 days compared to control which is usually 3 days as per FSSR, 2011 regulations. The findings in the present study are similar with Na et al. (2013), Hecer and Guldas (2011) and More et al. (2022) wherein they observed a reduction of TVC after decontamination with sodium hypochlorite, lactic acid and UV-C, respectively. The chlorine

TABLE 1: *Comparative effect of various decontaminants on microbial quality ($\log_{10}$ cfu/g) of raw chicken samples stored at 0–4°C.*

Microbial Parameter	Treatments	Storage Hours					Level of significance
		0	24	48	72	96	
TVC	Control (C)	$_{a}6.000\pm 0.12^{d}$	$_{a}6.364\pm 0.04^{c}$	$_{a}6.570\pm 0.04^{b}$	$_{a}6.866\pm 0.12^{a}$	$_{a}6.926\pm 0.14^{a}$	*
	Sodium h. (SH)	$_{ab}5.747\pm 0.19^{c}$	$_{a}6.086\pm 0.14^{b}$	$_{ab}6.435\pm 0.05^{a}$	$_{b}6.497\pm 0.04^{a}$	$_{b}6.585\pm 0.03^{a}$	*
	Lactic acid (LA)	$_{c}5.341\pm 0.09^{d}$	$_{b}5.586\pm 0.07^{c}$	$_{c}6.213\pm 0.06^{b}$	$_{b}6.351\pm 0.06^{ab}$	$_{b}6.482\pm 0.03^{a}$	*
	UV-C light (UV)	$_{bc}5.430\pm 0.05^{b}$	$_{b}5.603\pm 0.07^{b}$	$_{bc}6.322\pm 0.10^{a}$	$_{b}6.384\pm 0.10^{a}$	$_{b}6.491\pm 0.04^{a}$	*
	Level of significance	*	*	*	*	*	
E. coli	Control (C)	$_{a}2.200\pm 0.116^{c}$	$_{a}2.489\pm 0.098^{c}$	$_{a}2.960\pm 0.132^{b}$	$_{a}3.573\pm 0.285^{a}$	$_{a}3.667\pm 0.309^{a}$	*
	Sodium h. (SH)	$_{a}1.954\pm 0.111^{d}$	$_{b}2.184\pm 0.106^{c}$	$_{b}2.574\pm 0.174^{b}$	$_{b}2.741\pm 0.142^{b}$	$_{b}3.038\pm 0.191^{a}$	*
	Lactic acid (LA)	$_{b}1.482\pm 0.302^{c}$	$_{b}2.047\pm 0.105^{b}$	$_{c}2.339\pm 0.094^{ab}$	$_{b}2.523\pm 0.102^{a}$	$_{c}2.681\pm 0.140^{a}$	*
	UV-C light (UV)	$_{a}1.925\pm 0.105^{c}$	$_{b}2.155\pm 0.068^{c}$	$_{bc}2.479\pm 0.048^{b}$	$_{b}2.706\pm 0.093^{ab}$	$_{bc}2.787\pm 0.089^{a}$	*
	Level of significance	*	*	*	*	*	
Staphylococcus spp.	Control (C)	$_{a}2.433\pm 0.086^{c}$	$_{a}2.542\pm 0.064^{bc}$	$_{a}2.761\pm 0.109^{b}$	$_{a}3.195\pm 0.233^{a}$	$_{a}3.412\pm 0.221^{a}$	*
	Sodium h. (SH)	$_{b}2.212\pm 0.039^{e}$	$_{b}2.312\pm 0.051^{d}$	$_{b}2.499\pm 0.045^{c}$	$_{b}2.696\pm 0.040^{b}$	$_{b}2.815\pm 0.027^{a}$	*
	Lactic acid (LA)	$_{b}2.095\pm 0.048^{d}$	$_{b}2.227\pm 0.044^{c}$	$_{b}2.386\pm 0.033^{b}$	$_{b}2.451\pm 0.039^{b}$	$_{b}2.653\pm 0.012^{a}$	*
	UV-C light (UV)	$_{b}2.154\pm 0.021^{e}$	$_{b}2.316\pm 0.032^{d}$	$_{b}2.451\pm 0.029^{c}$	$_{b}2.612\pm 0.054^{b}$	$_{b}2.733\pm 0.046^{a}$	*
	Level of significance	*	*	*	*	*	
Yeast and mould	Control (C)	$_{a}2.327\pm 0.069^{c}$	2.505 ± 0.080^{bc}	2.569 ± 0.080^{b}	2.619 ± 0.074^{ab}	2.762 ± 0.093^{a}	*
	Sodium h. (SH)	$_{a}2.147\pm 0.131^{c}$	2.301 ± 0.151^{bc}	2.410 ± 0.127^{ab}	2.476 ± 0.137^{ab}	2.501 ± 0.171^{a}	*
	Lactic acid (LA)	$_{b}1.513\pm 0.313^{b}$	2.302 ± 0.043^{a}	2.453 ± 0.078^{a}	2.544 ± 0.081^{a}	2.627 ± 0.094^{a}	*
	UV-C light (UV)	$_{a}2.026\pm 0.079^{d}$	2.280 ± 0.051^{c}	2.408 ± 0.079^{bc}	2.518 ± 0.106^{ab}	2.619 ± 0.069^{a}	*
	Level of significance	*	NS	NS	NS	NS	

a, b, c, d, e means with different superscripts in a row differ significantly *p<0.05. a, b, c means with different subscripts in a column differ significantly *p<0.05. NS: Non significance.

compound shows a bactericidal effect by inhibiting glucose oxidation in the bacteria (Hecer et al., 2007). The antibacterial action of lactic acid is assigned to its penetration in the cytoplasmic membrane, resulting in reduced intracellular pH and destruction of the transmembrane proton motive force (Ray and Sandine, 1992). Philip et al. (2020) reported that the DNA of bacterial cells absorbs UV-C light and leads to a mutation that blocks the ability of DNA to replicate which leads to the destruction of the cells.

Differential count

E. coli: The result of the mean *E. coli* count of 'C' group chicken carcasses in comparison with carcasses decontaminated by 'SH', 'LA' and 'UV' groups are presented in Table 1. All the treatment groups significantly ($p<0.05$) delayed the growth of *E. coli* when compared with 'C' group. The *E. coli* count of 'C' group exceeded the regulated limit of 3 $\log_{10}$ cfu/g (FSSR, 2011) on 72 hours, whereas 'SH' group exceeded the same on 96 hours of storage. The *E. coli* values of 'LA' and 'UV' groups were found below the regulatory levels on 96 hours of storage. The results indicate that 'LA' and 'UV' treatments were found to be effective in controlling *E. coli* count during the storage of chicken at 0–4°C.

The results are in agreement with Northcutt et al. (2005) wherein, the rinsing of carcasses with 50 ppm chlorine water reduced *E. coli* count. He further reported that the 12-min holding time used was found sufficient to allow the bacteria to become attached, but carcass washing with 50 ppm chlorine water was sufficient to remove bacteria. Several researchers reported the effective use of lactic acid in the reduction of *E. coli* from raw chicken carcasses (Hecer and Guldas, 2011). Similarly, More et al. (2022) observed a reduction in *E. coli* count after the use of UV-C light irradiation on chicken carcasses with variable doses (103.93–415.75 mJ/cm^2).

Staphylococcus aureus: The results are given in Table 1. The results of statistical analysis indicate that on day '0' treatment, groups showed a significant ($p<0.05$) effect on *Staphylococcus* count compared to the control. The *Staphylococcus* count remained lower than 3 $\log_{10}$ cfu/g until 96 hours of storage only in treatment groups while for the control group it was higher than 3 $\log_{10}$ cfu/g. The results indicate that 'SH', 'LA' and 'UV' decontamination groups of raw chicken carcasses could be able to control the *Staphylococcus* count until 96 hours of storage.

The obtained results are in agreement with Saad et al. (2015) who found that chlorine (50 ppm) and Lactic acid (2%) dip reduced *Staphylococcus aureus* count to 4.78±0.13 and 4.09±0.29 log CFU/g, respectively from the initial count of 5.67 log CFU/g. McLeod et al. (2018) reported that increasing the UV dose increased the reduction rate in the *Staphylococcus aureus* count inoculated on chicken. The rough surface of foods possibly helped microorganisms to avoid UV irradiation exposure (Yemmireddy et al., 2022).

Yeast and mould: The results of yeast and mould analysis for raw chicken carcasses treated with the 'SH', 'LA' and 'UV' groups stored at refrigeration temperature (0–4°C) are presented in Table 1. A significant ($p<0.05$) effect of lactic acid treatment was seen on yeast and mould count immediately after the treatment at 0 hour. A statistically non-significant effect was observed for yeast and mould count irrespective of storage hours and treatment groups. All the values were found to be within the prescribed limits of process hygiene criteria for fresh meat as per the FSSAI regulations, 2011. Results are in agreement with the results obtained by Shewail et al. (2018) who found that lactic acid (1 and 2%) and sodium salt (2.5 and 5%) solution treatments were effective against the proliferation of yeast and mould on beef. Further, Manzocco et al., (2016) reported

TABLE 2: *Comparative effect of various decontaminants on physicochemical quality of raw chicken samples stored at 0–4°C.*

Physicochemical Parameter.	Treatments	Hours					Level of significance
		0	24	48	72	96	
pH	Control (C)	6.283 ± 0.125^{b}	${}_{a}6.263 \pm 0.067^{b}$	${}_{a}6.375 \pm 0.070^{b}$	${}_{a}6.533 \pm 0.086^{a}$	${}_{a}6.665 \pm 0.090^{a}$	*
	Sodium hypochlorite (SH)	6.210 ± 0.144^{c}	${}_{a}6.318 \pm 0.051^{c}$	${}_{a}6.407 \pm 0.060^{bc}$	${}_{a}6.592 \pm 0.102^{ab}$	${}_{a}6.640 \pm 0.104^{a}$	*
	Lactic acid (LA)	6.132 ± 0.128^{b}	${}_{b}6.063 \pm 0.065^{b}$	${}_{b}6.165 \pm 0.081^{ab}$	${}_{b}6.228 \pm 0.086^{ab}$	${}_{b}6.328 \pm 0.065^{a}$	*
	UV-C light (UV)	6.203 ± 0.156^{d}	${}_{a}6.268 \pm 0.081^{cd}$	${}_{a}6.388 \pm 0.049^{bc}$	${}_{a}6.470 \pm 0.034^{ab}$	${}_{a}6.572 \pm 0.037^{a}$	*
	Level of significance	NS	*	*	*	*	
TBARS (mg MDA/kg)	Control (C)	0.198 ± 0.040^{d}	${}_{b}0.230 \pm 0.041^{cd}$	${}_{b}0.272 \pm 0.044^{bc}$	${}_{b}0.321 \pm 0.037^{b}$	${}_{b}0.399 \pm 0.039^{a}$	*
	Sodium hypochlorite (SH)	0.160 ± 0.034^{d}	${}_{b}0.185 \pm 0.042^{cd}$	${}_{b}0.243 \pm 0.051^{c}$	${}_{b}0.311 \pm 0.056^{b}$	${}_{b}0.387 \pm 0.061^{a}$	*
	Lactic acid (LA)	0.278 ± 0.045^{b}	${}_{a}0.467 \pm 0.068^{b}$	${}_{a}0.701 \pm 0.085^{a}$	${}_{a}0.858 \pm 0.073^{a}$	${}_{a}0.887 \pm 0.176^{a}$	*
	UV-C light (UV)	0.195 ± 0.038^{c}	${}_{b}0.200 \pm 0.038^{c}$	${}_{b}0.252 \pm 0.039^{c}$	${}_{b}0.334 \pm 0.045^{b}$	${}_{b}0.402 \pm 0.035^{a}$	*
	Level of significance	NS	*	*	*	*	
P.V. (meq/kg)	Control (C)	${}_{b}0.117 \pm 0.019^{c}$	${}_{b}0.167 \pm 0.021^{c}$	0.333 ± 0.017^{b}	0.472 ± 0.067^{b}	${}_{b}0.700 \pm 0.115^{a}$	*
	Sodium hypochlorite (SH)	${}_{ab}0.172 \pm 0.061^{d}$	${}_{b}0.211 \pm 0.068^{cd}$	0.344 ± 0.068^{bc}	0.456 ± 0.111^{b}	${}_{b}0.639 \pm 0.170^{a}$	*
	Lactic acid (LA)	${}_{a}0.244 \pm 0.038^{d}$	${}_{a}0.378 \pm 0.048^{cd}$	0.561 ± 0.123^{bc}	0.650 ± 0.092^{b}	${}_{a}1.000 \pm 0.148^{a}$	*
	UV-C light (UV)	${}_{b}0.117 \pm 0.019^{c}$	${}_{b}0.200 \pm 0.068^{c}$	0.317 ± 0.111^{bc}	0.467 ± 0.180^{ab}	${}_{b}0.572 \pm 0.193^{a}$	*
	Level of significance	*	*	NS	NS	*	

a, b, c, d means with different superscripts in a row differ significantly *p<0.05. a, b means with different subscripts in a column differ significantly *p<0.05. NS- Non significance.

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that the growth of yeast was slower after UV-C treatment at 20 mJ/cm^2 and storage at 6°C for up to 15 days.

Salmonella spp.: In the current study, none of the raw chicken carcass samples from control as well as decontaminating treatment groups was found positive for *Salmonella* spp.

Physicochemical analysis

The storage related changes in physicochemical properties in raw chicken carcasses decontaminated with 'C', 'SH', 'LA' and 'UV' treatment at refrigeration temperature (0–4°C) are presented in Table 2.

pH: From Table 2, it is revealed that all the treatment groups showed statistically significant ($p<0.05$) increase in pH during the storage period. The 'LA' group showed statistically significant ($p<0.05$) lower pH compared to the 'C', 'SH' and 'UV' groups during the storage period of 96 hours.

Similar results were noted by Sinhamahapatra et al. (2004) for pH of chicken treated with 50 ppm chlorine solution for 5 min in the form of dips and sprays. In another study, More et al. (2022) found that the initial pH value of chicken breast was 5.970 ± 0.115 and 5.610 ± 0.115 for UV-C irradiation and sodium hypochlorite decontamination treatment, respectively. During 96 hours of storage, the pH value of chicken leg meat decontaminated with lactic acid treatment was found to be acidic in comparison with other treatment groups. Yang et al. (2017) reported that there were no significant differences ($p > 0.05$) in pH (up to 48 hr) due to UV-C treatment (600–2400 mWs/cm²). Nearly similar results were obtained by Heir et al. (2022) who reported that the lactic acid treatments provided a pH drop to pH 5.8–6.2 at day 1 but values increased to pH 6.0–6.6 after 20 days storage.

Thiobarbituric acid-reactive substances (TBARS) value: Results of TBARS values are given in Table 2. The level of oxidative rancidity was found to increase over that duration of storage but remained very low for all samples except the lactic acid treatment group over storage duration and treatments. The average TBARS value throughout storage time for lactic acid (2%) was significantly higher ($p<0.05$) versus other groups. TBARS value of the 'LA' group at 96 hours reached near to the maximum recommended limit of TBARS value (0.9 mg MDA/kg) as stated by EOS, 2005.

Saleh et al. (2022) reported mean TBA values of 0.33 ± 0.01 mg/kg after dipping chicken meat in distilled water for 5 minutes. The values in the current study for control are lower than the values mentioned by Saleh et al. (2022). Similarly, More et al. (2022) reported significantly higher TBA values (0.700 ± 0.019 mg MDA/kg) on 72 hours of storage for chicken carcasses decontaminated with 50 ppm Sodium hypochlorite. Duan et al. (2017) reported significantly higher TBARS values for chicken samples after the application of 2% lactic acid and stated that lactic acid treatment accelerates lipid oxidation. Various research workers reported that UV-C treatment had no significant effect on the lipid oxidation of meat samples stored at refrigeration temperature (Canto et al., 2019).

Peroxide value (POV): The degree of lipid oxidation indexed by peroxide value. A higher peroxide value denotes that more intermediate lipid oxidation products are accumulated (Liu et al., 2019; More et al., 2022).

From Table 2, it is evident that peroxide value underwent significantly ($p<0.05$) increased changes during 96 hours of storage for all treatment groups. The samples treated with 2% lactic acid showed significantly ($p<0.05$) higher peroxide value (POV) on each hour of sampling compared to other treatment groups. The results are in agreement with Biswas et al. (2017) who reported a gradual significant increase in peroxide value with the advancement of storage period for chicken and fish samples. Numerically all the values were far below of recommended value of 20–40 meq/kg (Low and Ng, 1992). The data was supported by the findings of More et al., (2022) wherein, they reported considerably ($p<0.05$) greater POV values of raw chicken carcasses treated with UV-C light compared to sodium hypochlorite treated samples. Dhakal et al., (2020) also reported greater peroxide value for rendered chicken fat treated with lactic acid.

Sensory analysis

Table 3 denotes the means of colour, odour and overall acceptability for the examined chicken samples with 9 point Hedonic scale ranging between 'dislike extremely' to 'like

TABLE 3: *Effect of various decontaminants on the sensory quality of chicken samples stored at 0–4°C.*

Sensory Parameter	Treatments	Hours					Level of significance
		0	24	48	72	96	
Colour	Control (C)	$_{a}8.9\pm 0.12^{a}$	$_{a}8.4\pm 0.13^{b}$	$_{b}7.6\pm 0.17^{c}$	$_{b}7.1\pm 0.08^{d}$	$_{b}6.5\pm 0.10^{e}$	*
	Sodium hypochlorite (SH)	$_{a}9.0\pm 0.04^{a}$	$_{a}8.5\pm 0.14^{b}$	$_{a}8.2\pm 0.15^{c}$	$_{a}7.8\pm 0.21^{d}$	$_{a}7.3\pm 0.11^{e}$	*
	Lactic acid (LA)	$_{b}7.9\pm 0.08^{a}$	$_{b}6.9\pm 0.49^{b}$	$_{c}6.8\pm 0.42^{b}$	$_{c}6.3\pm 0.40^{bc}$	$_{b}6.1\pm 0.36^{c}$	*
	UV-C light (UV)	$_{a}8.9\pm 0.08^{a}$	$_{a}8.4\pm 0.24^{b}$	$_{ab}7.9\pm 0.24^{c}$	$_{ab}7.6\pm 0.22^{c}$	$_{a}7.5\pm 0.13^{c}$	*
	Level of significance	*	*	*	*	*	
Odour	Control (C)	$_{a}8.8\pm 0.10^{a}$	$_{ab}8.2\pm 0.23^{b}$	$_{a}7.5\pm 0.20^{c}$	$_{b}6.9\pm 0.06^{d}$	$_{b}6.1\pm 0.15^{e}$	*
	Sodium hypochlorite (SH)	$_{a}8.7\pm 0.10^{a}$	$_{a}8.3\pm 0.20^{b}$	$_{a}8.0\pm 0.19^{b}$	$_{ab}7.2\pm 0.30^{c}$	$_{a}7.1\pm 0.22^{c}$	*
	Lactic acid (LA)	$_{c}7.0\pm 0.20^{a}$	$_{c}6.4\pm 0.30^{b}$	$_{b}6.4\pm 0.32^{b}$	$_{c}6.2\pm 0.17^{bc}$	$_{b}5.9\pm 0.25^{c}$	*
	UV-C light (UV)	$_{b}7.9\pm 0.13^{a}$	$_{b}7.9\pm 0.08^{a}$	$_{a}7.8\pm 0.16^{ab}$	$_{a}7.5\pm 0.18^{bc}$	$_{a}7.2\pm 0.23^{c}$	*
	Level of significance	*	*	*	*	*	
Overall acceptability	Control (C)	$_{a}8.8\pm 0.09^{a}$	$_{a}8.4\pm 0.09^{b}$	$_{a}7.8\pm 0.16^{c}$	$_{b}7.1\pm 0.14^{d}$	$_{b}6.3\pm 0.11^{e}$	*
	Sodium hypochlorite (SH)	$_{a}9.0\pm 0.03^{a}$	$_{a}8.6\pm 0.16^{b}$	$_{a}8.3\pm 0.11^{bc}$	$_{a}8.0\pm 0.15^{c}$	$_{a}7.4\pm 0.19^{d}$	*
	Lactic acid (LA)	$_{b}7.6\pm 0.16^{a}$	$_{b}6.9\pm 0.40^{b}$	$_{b}6.9\pm 0.32^{b}$	$_{b}6.4\pm 0.34^{c}$	$_{b}6.1\pm 0.25^{c}$	*
	UV-C light (UV)	$_{a}8.8\pm 0.09^{a}$	$_{a}8.5\pm 0.23^{b}$	$_{a}8.0\pm 0.19^{c}$	$_{a}7.9\pm 0.20^{c}$	$_{a}7.4\pm 0.22^{d}$	*
	Level of significance	*	*	*	*	*	

a, b, c, d, e means with different superscripts in a row differ significantly *p<0.05. a, b, c means with different subscripts in a column differ significantly *p<0.05.

extremely'. There was a significant ($p<0.05$) decrease in values of colour, odour and overall acceptability in all treatment groups up to 96 hours stored at refrigeration temperature (0–4°C). On the initial day of sensory evaluation, the sensory score of the lactic acid treatment group was significantly ($p<0.05$) lower than other treatment groups.

Colour score: The non-significant difference after 96 hours of storage was observed within the 'C' and 'LA' groups, as well as, within the 'SH' and 'UV' groups. The lower colour score was observed for the 'LA' group but all the samples analyzed were considered acceptable during sensory analysis. These results are in agreement with Burfoot and Mulvey (2011), who reported slight paling of skin and greying of fat after the use of lactic acid spray for the decontamination of the chicken carcass.

Odour score: At 96 hours of refrigeration storage (0–4°C) non-significant difference in odour score was observed between the 'C' and 'LA' groups but both showed significantly ($p<0.05$) lower odour scores than the 'SH' and 'UV' groups. Shewail et al., 2018 reported an acidic odour and lower odour score after lactic acid treatment which are in agreement with the current study.

Overall acceptability score: As per Table 3, it is evident that overall acceptability was significantly ($p<0.05$) lower in the 'LA' group compared to the 'C', 'SH' and 'UV' groups, which continued till 48 hours of storage (0–4°C). From the previous studies, we found that sodium hypochlorite and UV-C had shown a non-significant effect on the overall acceptability of chicken samples (Park and Ha, 2015). Shewail et al. (2018) reported the lowest acceptability scores among the samples treated with 2% lactic acid which is in agreement with the current study.

Instrumental colour analysis

The results are depicted in Table 4 and Figure 1. No significant difference was found in L*, a* and b* values for all decontaminated raw chicken carcass groups. The main effect of storage was significant ($p<0.05$) on L* and a* values of raw chicken carcasses decontaminated with the 'C', 'SH', 'LA' and 'UV' groups. Overall L* values tended to incline while a* values decline for all treatment groups. Our results are in agreement with earlier reports, wherein instrumental colour values of chicken carcasses were observed to vary as per the decontamination with the sodium hypochlorite, lactic acid and UV-C light (Anang et al., 2010; Lee et al., 2014; Wang et al., 2021).

Instrumental tenderness analysis

Texture Profile Analysis (TPA) parameters of all samples on 0 and 96 hours of storage are depicted in Table 5 and Figure 2. The reduction was observed in the Hardness,

TABLE 4: *Results of change in Hunter colour values of decontaminant treatments of raw chicken carcasses on 0 and 4th day of storage at 0–4°C.*

Hunter colour values Parameter	Treatments	0 Hour	96 Hour	Level of significance
Lightness (L*)	Control (C)	51.66 ± 0.24^{b}	59.52 ± 0.82^{a}	*
	Sodium hypochlorite (SH)	51.36 ± 1.94^{b}	58.22 ± 1.38^{a}	*
	Lactic acid (LA)	56.04 ± 1.20^{b}	61.36 ± 2.15^{a}	*
	UV-C light (UV)	51.99 ± 2.10^{b}	59.92 ± 3.16^{a}	*
	Level of significance	NS	NS	
Redness (a*)	Control (C)	7.22 ± 0.09^{a}	5.54 ± 0.58^{b}	*
	Sodium hypochlorite (SH)	7.44 ± 0.25^{a}	5.67 ± 0.45^{b}	*
	Lactic acid (LA)	8.47 ± 0.84^{a}	6.56 ± 0.55^{b}	*
	UV-C light (UV)	7.15 ± 0.35^{a}	5.39 ± 0.38^{b}	*
	Level of significance	NS	NS	
Yellowness (b*)	Control (C)	17.64 ± 0.31^{b}	19.07 ± 0.52^{a}	*
	Sodium hypochlorite (SH)	17.30 ± 1.08	18.77 ± 0.46	NS
	Lactic acid (LA)	19.71 ± 0.43	20.38 ± 1.44	NS
	UV-C light (UV)	17.99 ± 0.53	19.49 ± 1.23	NS
	Level of significance	NS	NS	

a, b means with different superscripts in a row differ significantly *p<0.05. NS: Non significance.

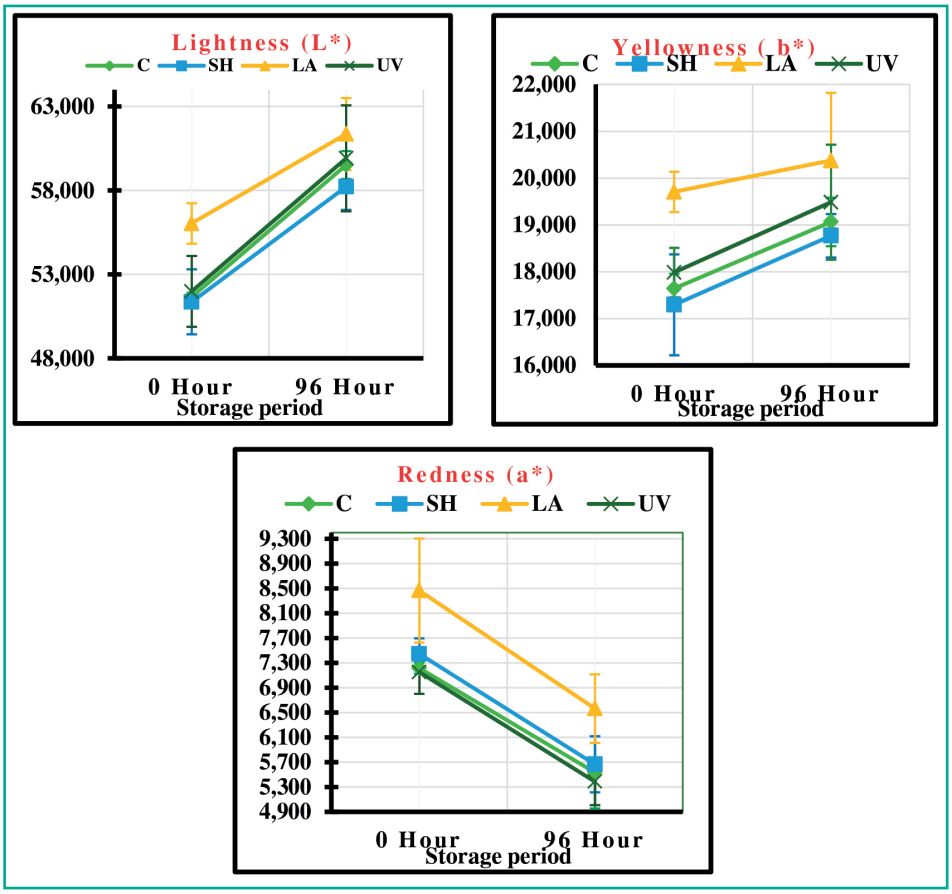

FIGURE 1: *Effect of various decontaminants on change in Hunter colour L*, a* and b* values of raw chicken carcasses on 0 and 4th day of storage at 0–4°C*

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Springiness, Cohesiveness, Gumminess and Chewiness values of all chicken breast samples on 96 hours of storage. At the end of the storage period, a non-significant difference in the hardness, springiness, cohesiveness and chewiness was observed in all treatment groups. The gumminess value only showed a statistically significant ($p<0.05$) reduction after 96 hours of storage for the 'C', 'SH' and 'UV' groups. The results showed a negative correlation between the TPA values and various decontamination methods. Various researchers reported no significant changes in the texture properties of meat including hardness, springiness, cohesiveness, gumminess and chewiness, treated with various decontaminant (Wang et al., 2021).

TABLE 5: *Results of Instrumental tenderness (Texture Profile Analysis) of raw chicken samples during storage (0–4°C) treated with various decontaminants.*

TPA Instrumental Parameter	Treatments	Control (C)	Sodium hypochlorite (SH)	Lactic acid (LA)	UV-C light (UV)	Level of significance
Hardness (g)	0 Hour	9158.272 ± 1292.781	9146.75 ± 360.72	9267.13 ± 1607.52	9200.60 ± 531.35	NS
	96 Hour	7277.640 ± 390.736	7802.31± 943.79	7911.97 ± 439.10	7772.27 ± 250.90	NS
	Level of significance	NS	NS	NS	NS	
Springiness	0 Hour	0.710 ± 0.028	0.692 ± 0.04	0.747± 0.01	0.677 ± 0.05	NS
	96 Hour	0.667 ± 0.038	0.667 ± 0.05	0.658 ± 0.04	0.645 ± 0.03	NS
	Level of significance	NS	NS	NS	NS	
Cohesiveness	0 Hour	0.482 ± 0.020	0.470 ± 0.03	0.483 ± 0.03	0.488 ± 0.03	NS
	96 Hour	0.450 ± 0.018	0.433 ± 0.02	0.424 ± 0.06	0.455 ± 0.02	NS
	Level of significance	NS	NS	NS	NS	
Gumminess	0 Hour	$_{a}$4952.630 ± 663.580	$_{a}$4862.54 ± 180.37	4736.88 ± 1188.80	$_{a}$4740.76 ± 80.19	NS
	96 Hour	$_{b}$3525.761 ± 244.779	$_{b}$3347.87 ± 490.47	3635.93 ± 335.32	$_{b}$3492.03 ± 40.86	NS
	Level of significance	*	*	NS	*	
Chewiness	0 Hour	3346.072 ± 413.006	3092.09 ± 377.72	3378.60 ± 380.00	3488.63 ± 414.74	NS
	96 Hour	2312.348 ± 204.460	2219.92 ± 329.38	2431.23 ± 1108.29	2744.54 ± 183.07	NS
	Level of significance	NS	NS	NS	NS	

a, b means with different superscripts in a row differ significantly *$p<0.05$. NS: Non significance.

Conclusions

The Food Safety Standard Authority of India (FSSAI) permit the use of sodium hypochlorite as an antimicrobial agent in meat, whereas lactic acid and UV-C light has not been listed under the stated category (FSSAI, 2011). The use of lactic acid in cattle carcasses is permitted by European Union (EU) directive 101/2013 published in 2013 (Cil et al., 2019). Similarly, the United States Food and Drug Administration (USFDA) defines UV-C radiation as a food additive and regulates the use of UV-C technology at the appropriate level (USFDA, 2018). In the current study sodium hypochlorite, lactic acid and UV-C light decontaminants were found to extend the shelf life of chicken up to 4 days at refrigeration storage (0–4°C) but based on microbial, physicochemical and sensory qualities, UV-C light (415.75 mJ/cm^2) decontamination technique was found more effective.

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Conflicts of interest

The authors declare no conflicts of interest.

References

Althaus D, Zweifel C, Stephan R (2017): Analysis of a poultry slaughter process: Influence of process stages on the microbiological contamination of broiler carcasses. Italian journal of food safety, 6(4).

Anang DM, Rusul G, Ling FH, Bhat R (2010): Inhibitory effects of lactic acid and lauricidin on spoilage organisms of chicken breast during storage at chilled temperature. International journal of food microbiology, 144(1): 152–159.

AOAC (1995): Official methods of analysis 16th Ed. Association of official analytical chemists. Washington DC, USA. Sci. Educ.

BAHS (2022): Animal Husbandry Statistics Division. Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India.

Bilgili SF (2009): Antimicrobials approved for poultry processing in the US. WOGS fact sheet.

Biswas O, Talwar NA, Bhattacharya D, Das SK, Chaudhary S (2017): Effect of refrigeration on quality and stability of fresh fish and poultry muscles. Indian J Anim Health, 56(1): 65–76.

Biswas S, Chakraborty A, Sarkar S, Barpuzari RN, Barpuzari T (2007): Effect of incorporation of chicken fat and skin on the quality of chicken sausages. The Journal of Poultry Science, 44(1): 111–115.

Block SS (Ed.) (2001): Disinfection, sterilization, and preservation. Lippincott Williams and Wilkins.

Burfoot D, Mulvey E (2011): Reducing microbial counts on chicken and turkey carcasses using lactic acid. Food Control, 22(11): 1729–1735.

Byun KH, Han SH, Yoon JW, Park SH, Ha SD (2021): Efficacy of chlorine-based disinfectants (sodium hypochlorite and chlorine dioxide) on Salmonella Enteritidis planktonic cells, biofilms on food contact surfaces and chicken skin. Food Control, 123: 107838.

Canto ACVDCS, Monteiro MLG, Costa-Lima BRCD, Lázaro CA, Marsico ET, Silva TJPD, Conte-Junior CA (2019): Effect of UV-C radiation on Salmonella spp. reduction and oxidative stability of caiman (Caiman crocodilus yacare) meat. Journal of Food Safety, 39(2): e12604.

Capita R, Alonso-Calleja, C, Sierra M, Moreno B, del Camino García-Fernández M (2000): Effect of trisodium phosphate solutions washing on the sensory evaluation of poultry meat. Meat science, 55(4): 471–474.

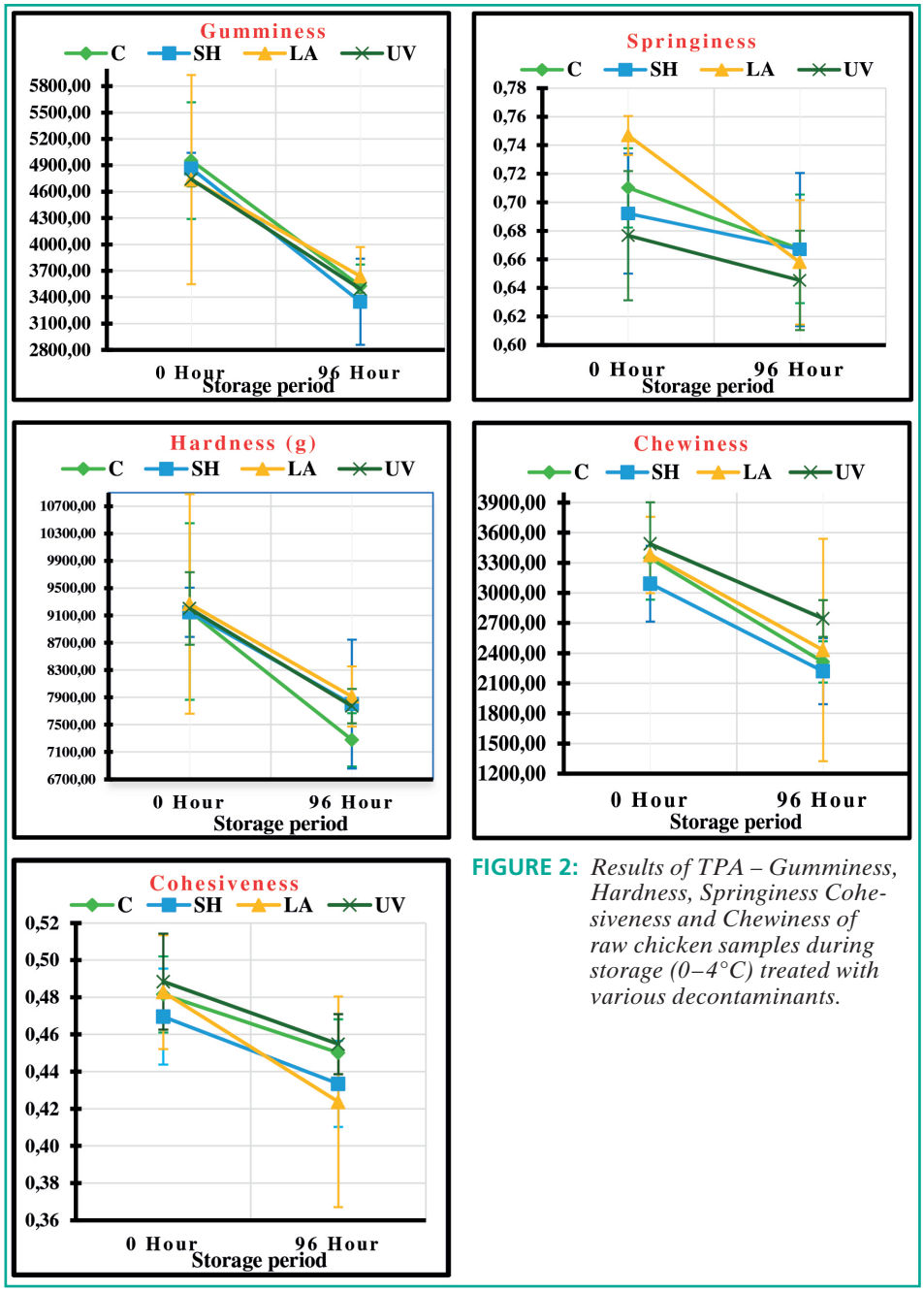

FIGURE 2: *Results of TPA – Gumminess, Hardness, Springiness Cohesiveness and Chewiness of raw chicken samples during storage (0–4°C) treated with various decontaminants.*

Chouliara E, Karatapanis A, Savvaidis IN, Kontominas MG (2007): Combined effect of oregano essential oil and modified atmosphere packaging on shelf-life extension of fresh chicken breast meat, stored at 4 C. Food microbiology, 24(6): 607–617.

Cil GI, Ozdemir H, Onaran B, Cengiz G, Erdi SEN (2019): Effect of lactic acid and steam treatments on Campylobacter jejuni on chicken skin. Emirates Journal of Food and Agriculture, 31(2), 143–147.

Dhakal J, Holt D, Aldrich C, Knueven C (2020): Effects of antimicrobial addition on shelf life of rendered chicken fat. Authorea Preprints.

Duan D, Wang H, Xue S, Li M, Xu X (2017): Application of disinfectant sprays after chilling to reduce the initial microbial load and extend the shelf-life of chilled chicken carcasses. Food Control, 75: 70–77.

EOS (2005): Egyptian Organization for Standards and Quality Control: Detection of poisons and control. Report No. 1796.

FAO O (2021): Meat. OECD-FAO Agricultural Outlook 2021–2030, 163–177.

Faustman C, Cassens RG (1990): The biochemical basis for discoloration in fresh meat: a review. Journal of muscle Foods, 1(3): 217–243.

FDA U (1999): Irradiation in the production, processing and handling of food. Ionizing radiation for the treatment of food. Code of Federal Regulations 21CFR179, 26.

FSSAI (2011): https://fssai.gov.in/cms/food-safety-and-standards-rules--2011.php Dt.10/01/2023.

FSSR (2011): Compendium on Food Safety and Standards (Food Products Standards and Food Additives) Regulations, 2011 India. Chapter 2.5 (Meat and Meat Products). https://www.fssai.gov.in/cms/Compendium-FSS-FPS-FA.php

González-Alonso V, Cappelletti M, Bertolini FM, Lomolino G, Zambon A, Spilimbergo S (2020): Research Note: Microbial inactivation of raw chicken meat by supercritical carbon dioxide treatment alone and in combination with fresh culinary herbs. Poultry science, 99(1): 536–545.

Guerrero-Beltrń JA, Barbosa-Cńovas GV (2004): Advantages and limitations on processing foods by UV light. Food science and technology international, 10(3): 137–147.

Hecer C, Guldas M (2011): Effects of lactic acid, fumaric acid and chlorine dioxide on shelf-life of broiler wings during storage. African Journal of Agricultural Research, 23, 3880–3883.

Hecer C, Balci F, Udum CD (2007): The effects of ozone and chlorine applications on microbiological quality of chickens during processing. Journal of Biological and Environmental Sciences, 1(3).

Heir E, Solberg LE, Jensen MR, Skaret J, Grøvlen MS, and Holck AL (2022): Improved microbial and sensory quality of chicken meat by treatment with lactic acid, organic acid salts and modified atmosphere packaging. International Journal of Food Microbiology, 362: 109498.

ISO 16649-2 (2001): Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of beta-glucuronidase-positive Escherichia coli – Part 2: Colony-count technique at 44 degrees C using 5-bromo-4-chloro-3-indolyl beta-D-glucuronide. International Organization for Standardization, Geneva, Switzerland.

ISO 17604 (2015): Microbiology of the Food Chain – Carcass Sampling for Microbiological Analysis. International Organization for Standardization: Geneva, Switzerland.

ISO 21527-1 (2008): Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of yeasts and moulds – Part 1: Colony count technique in products with water activity greater than 0.95. International Organization for Standardization, Geneva, Switzerland.

ISO 4833-1 (2013): Microbiology of the food chain – Horizontal method for the enumeration of microorganisms – Part 1: Colony count at 30 °C by the pour plate technique. International Organization for Standardization, Geneva, Switzerland.

ISO 6579-1 (2017): Microbiology of the food chain – Horizontal method for the detection, enumeration and serotyping of Sal-

monella – Part 1: Detection of Salmonella spp. International Organization for Standardization, Geneva, Switzerland.

ISO 6888-1 (2021): Microbiology of the food chain – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) – Part 1: Method using Baird-Parker agar medium. International Organization for Standardization, Geneva, Switzerland.

Izat AL, Gardner FA, Denton JH, Golan FA (1988): Incidence and level of Campylobacter jejuni in broiler processing. Poultry Science, 67(11): 1568–1572.

James C, Vincent C, de Andrade Lima TI, James SJ (2006): The primary chilling of poultry carcasses – a review. International Journal of Refrigeration, 29(6): 847–862.

Lamber AD, Smith JP, Dodds KL (1991): Shelf life extension and microbiological safety of fresh meat – a review. Food Microbiology, 8(4): 267–297.

Lee NY, Park SY, Kang IS, and Ha SD (2014): The evaluation of combined chemical and physical treatments on the reduction of resident microorganisms and Salmonella Typhimurium attached to chicken skin. Poultry Science, 93(1): 208–215.

Low LK and Ng CS. (1992): Training Manual on Fish Quality Preservation. Marine Fisheries Research Department. Southeast Asian Fisheries Development Center. Singapore. 271p.

Lim W, Harrison MA (2016): Effectiveness of UV light as a means to reduce Salmonella contamination on tomatoes and food contact surfaces. Food Control, 66: 166–173.

Liu N, Zhu Q, Zeng X, Yang B, Liang M, Hu, P, Zhou J (2019): Influences of pulsed light-UV treatment on the storage period of dry-cured meat and shelf life prediction by ASLT method. Journal of food science and technology, 56: 1744–1756.

McLeod A, Hovde Liland K, Haugen JE, Sørheim O, Myhrer KS, Holck AL (2018): Chicken fillets subjected to UV-C and pulsed UV light: Reduction of pathogenic and spoilage bacteria, and changes in sensory quality. Journal of food safety, 38(1): e12421.

Manzocco L, Plazzotta S, Maifreni M, Calligaris S, Anese M, Nicoli MC (2016): Impact of UV-C light on storage quality of fresh-cut pineapple in two different packages. LWT – Food Science and Technology, 65: pp. 1138-1143 https://doi.org/10.1016/j.lwt.2015.10.00

More KD, Waghamare RN, Deshmukh VV, Londhe SV, Khose KK (2022): Use of Ultraviolet Light for Surface Decontamination of Raw Chicken Carcasses. Journal of Experimental Agriculture International, 44(11): 226–239.

Morshedy AEMA, Sallam KI (2009): Improving the microbial quality and shelf life of chicken carcasses by trisodium phosphate and lactic acid dipping. International Journal of Poultry Science, 8(7): 645–650.

Na JC, Kim SH, Jung S, Lee SK, Kang HG, Choi HC, Jo C (2013): The Effect of Washing of Carcasses with Sodium Hypochlorite Solution and Vacuum Packaging on the Microbiological and Physiochemical Quality of the Breast Meat from Old Hen during Storage at 4 °C. Korean Journal of Poultry Science, 40(4), 327–336.

Northcutt JK, Smith DP, Musgrove MT, Ingram KD, Hinton Jr A (2005): Microbiological impact of spray washing broiler carcasses using different chlorine concentrations and water temperatures. Poultry Science, 84(10): 1648–1652.

Park SY, Ha, SD (2015): Ultraviolet-C radiation on the fresh chicken breast: Inactivation of major foodborne viruses and changes in physicochemical and sensory qualities of the product. Food and Bioprocess Technology, 8: 895–906.

Philip AJ, Nikanjam N, Nowak E, Mutukumira AN (2020): Surface Pasteurisation of Fresh Chicken Meat using UV-C Technology. Engineering in Agriculture, Environment and Food, 13(4): 121–128.

Ray, B. and Sandine WF (1992): Acetic, propionic, and lactic acids of starter culture bacteria as biopreservatives, p. 103–136. In B. Ray and M. Daeschel (ed.), Food preservatives of microbial origin. CRC Press, Boca Raton, Fla.

Russell SM, Axtell S (2005): The effect of monochloramine versus chlorine on pathogenic, indicator, and spoilage bacteria associated with broiler chicken carcasses: A model, pilot scale, and industrial study. J. Food Prot, 68: 758–763.

Saad SM, Ibrahim HM, Amin RA, Hafez SM (2015): Decontamination of inoculated chicken carcasses by using some microbial decontaminators. Benha veterinary medical journal, 28(2): 83–90.

Saleh E, El-Morshdy AE, Aboelmkarm M (2022): Improvement of the Chemical and Microbial Quality of Marketed Chicken Meat Using Organic Acids. Damanhour Journal of Veterinary Sciences, 8(2), 16–21.

Sallam KI, Samejima K (2004): Microbiological and chemical quality of ground beef treated with sodium lactate and sodium chloride during refrigerated storage. LWT-Food Science and Technology, 37(8): 865–871.

Shewail A, Shaltout F, Gerges T (2018): Impact of some organic acids and their salts on microbial quality and shelf life of beef. Assiut Veterinary Medical Journal, 64(159): 164–177.

Shivaji A (2022): Effect of chlorine dioxide as a decontaminant on physico-chemical and microbiological parameters of chicken meat under refrigeration storage. The Pharma Innovation Journal, SP-11(4): 2007–2011.

Sinhamahapatra M, Biswas S, Das AK, Bhattacharyya D (2004): Comparative study of different surface decontaminants on chicken quality. British Poultry Science, 45(5): 624–630.

Sowmya T, Somsai T (2020): A Study on Evolution of Frozen Meat Products In Food Bussines. The Pharma Innovation Journal, (8): 06–09.

Strange ED, Benedict RC, Smith JL, Swift CE (1977): Evaluation of rapid tests for monitoring alterations in meat quality during storage: I. Intact meat. Journal of Food Protection, 40(12): 843–847.

Wang T, MacGregor SJ, Anderson JG, Woolsey GA (2005): Pulsed ultra-violet inactivation spectrum of Escherichia coli. Water research, 39(13): 2921–2925.

Wang W, Zhao D, Li K, Xiang Q, Bai Y (2021): Effect of UVC light-emitting diodes on pathogenic bacteria and quality attributes of chicken breast. Journal of Food Protection, 84(10): 1765–1771.

Yang S, Sadekuzzaman M, Ha SD (2017): Reduction of Listeria monocytogenes on chicken breasts by combined treatment with UV-C light and bacteriophage ListShield. Lwt, 86: 193–200.

Yemmireddy V, Adhikari A., Moreira J (2022): Effect of ultraviolet light treatment on microbiological safety and quality of fresh produce: An overview. Front. Nutr. 9:871243. doi: 10.3389/fnut.2022.87124

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