The Pharma Innovation Journal 2023; SP-12(9): 355-358

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(9): 355-358

www.thepharmajournal.com
Received: 01-06-2023
Accepted: 07-08-2023

A Shivaji
Department of Livestock Products Technology, P V Narsimha Rao Telangana Veterinary University, Hyderabad, Telangana, India

K Santosh
Department of Livestock Products Technology, P V Narsimha Rao Telangana Veterinary University, Hyderabad, Telangana, India

Muthukumar
Department of Livestock Products Technology, ICAR-National Research Centre on Meat, Hyderabad, Telangana, India

Shashikumar
Department of Livestock Products Technology, P V Narsimha Rao Telangana Veterinary University, Hyderabad, Telangana, India

Corresponding Author:
A Shivaji
Department of Livestock Products Technology, P V Narsimha Rao Telangana Veterinary University, Hyderabad, Telangana, India

Effect of chlorine dioxide on colour and sensory parameters of chicken meat under refrigerated storage

A Shivaji, K Santosh, Muthukumar and Shashikumar

Abstract
A study was carried out to determine the influence of different concentrations (50, 75 and 100 ppm) of chlorine dioxide (ClO_2) with a contact time of 10 minutes on chicken meat and the treatments along with control were evaluated for instrumental colour and sensory characteristics of chicken meat on 0th, 3rd, 5th and 7th day under refrigeration storage. Instrumental colour values i.e. L* (lightness), a* (redness) and b* (yellowness) were affected by all the concentrations of chlorine dioxide treatments and sensory evaluation revealed a decrease in the sensory scores for both control and 50 ppm chlorine dioxide treated samples with the advancement of storage but 75 and 100 ppm chlorine dioxide treated samples were better in retaining sensory qualities. From the present study, It can be concluded that chlorine dioxide can be used in decontamination of chicken carcasses and 100 ppm of chlorine dioxide treated poultry carcasses could be safely stored for 7 days under aerobic packaging at refrigerated temperature (4±1 ºC) without any undesirable changes in colour and organoleptic quality of chicken.

Keywords: Chicken meat, Chlorine dioxide, Decontamination, Instrumental colour

1. Introduction
Poultry meat is a commonly consumed food product in many countries because of its relatively low cost of production, low fat content, high nutritional value and distinct Odour and also having different types of processed poultry products. However, poultry meat is a highly perishable food product and they are subjected to modifications in their structure, composition and properties during storage before consumption. According to Lambert *et al.,* (1991) [4] the most significant spoilage of meat is done by microbial growth and influences the sensory properties of meat including appearance, texture, flavor, color, Odour and overall acceptability. Chlorine dioxide, sodium hypochlorite, lactic acid, peracetic acid are most commonly used disinfectants for commercial poultry processing (Duan *et al*., 2017) [3]. Chlorine dioxide has large bactericidal effects with several advantages over chlorinated water, including lower toxicities, more stable forms, making them promising candidates for replacing chlorinated water in the field of chicken processing (SCVPH, 2003; Burfoot and Mulvery, 2011) [6, 2]. It is legally permitted in China and USA for sanitizing fruit and vegetables in water and recommended by the World Health Organization (Zhu *et al*., 2013) [11]. Chlorine dioxide is approved by the USDA Food Safety Inspection Service as an antimicrobial chemical for poultry processing in scald tanks, pickers, carcass washers, and immersion chill tanks (USDA, 2006) [9]. However, its effect on carcass surface has not been attempted. Therefore the present study was initiated with the following objectives.

1. To study the effect of chlorine dioxide on the colour and sensory characteristics of chicken meat.

2. Materials and Methods
The study was conducted to compare the effect of different concentrations of chlorine dioxide on instrumental colour and sensory parameters of chicken meat under refrigeration storage.

2.1 Meat Sample
Broiler birds were procured from local market of Hyderabad and slaughtered in experimental abattoir of ICAR-National Research Centre on Meat, Hyderabad. After removing the skin, each carcass was split into 2 halves. Then the visible fat and connective tissue residues were removed using a sterile, sharp stainless steel knife.

These carcass were treated by dipping them in aqueous chlorine dioxide solutions at 50, 75, 100 ppm concentrations for about ten minutes and drained of excess water. The meat was packaged in LDPE bags and stored at 4±1 °C for a period of 7 days. This refrigerated meat was used for further studies.

2.2 Experimental design
Forty broiler birds were procured from local market of Hyderabad and slaughtered in experimental abattoir of ICAR-National Research Centre on Meat, Hyderabad by adopting traditional method and five trials were conducted each containing eight birds. After desking and evisceration process, eight carcasses were subjected to four treatments, two carcasses under each treatment as T_0 (without any treatment as control) and other six carcasses were treated by dipping in aqueous solution of chlorine dioxide of three different concentrations designated as T_1, T_2 and T_3 with 50, 75 and 100 ppm respectively. Instrumental colour and sensory characteristics of chicken meat were analyzed on 0th, 3rd, 5th & 7th day under refrigeration storage.

2.3 Analytical procedures
2.3.1 Hunter lab calorimeter colour values
The instrumental colour was measured using Hunter Lab apparatus (Lovibond-RT-500 series, serial number: 35177, WO-A26424, Dortmund, Germany) that had been calibrated against black and white reference tiles (X=78.6, Y=83.4, Z=89.0). Meat sample was placed below the disc of Hunter Lab apparatus. The Lightness (L*), Redness (a*), Yellowness (b*) colour units were recorded by comparing sample with that of standard.

2.3.2 Sensory analysis
The sensory quality of control as well as treatment samples was judged based on the characteristics of appearance, colour, Odour and sliminess. The samples were subjected to sensory evaluation by sensory panel consisting of a minimum of six members, repeating the evaluation thrice. The changes in the sensory parameters of all the samples were judged by the panel using four point descriptive scale for Odour and five point descriptive scale for colour of fresh meat and eight point descriptive scale for cooked meat given in the score sheet (Annexure-1).

2.5 Statistical analysis
The experiment was repeated three times in duplicate and the data generated for different meat quality parameters were compiled and analyzed using SPSS (version 20.0 for Windows; SPSS, Chicago. 111, U.S.A.). The data were subjected to analysis of variance, (oneway ANOVA between different groups and storage periods), least significant difference and Duncan's multiple range tests for comparing the means to find the difference between the groups and different storage periods. The smallest difference (D_5%) for two means was reported as significantly different (p<0.05).

3. Results and Discussion
3.1 Instrumental Colour
Instrumental colour values were affected by all the concentrations of chlorine dioxide treatments. The lightness values (L*) of chicken carcass increased as the storage period increased and the increase in the lightness values were substantial to the concentration of chlorine dioxide used. Chlorine dioxide treated samples were lighter in colour compared to control sample during entire storage period.

The redness values **(**a*) values consistently decreased during storage period. The a* values were higher in control samples than chlorine dioxide treated samples. The redness values **(**a*) of chlorine dioxide treated samples were low when compared to the control and on the 7th day of refrigeration storage, the redness values were significantly lower in 100 ppm chlorine dioxide treated samples and the redness values of the other treatments were also significantly differed with each other in both breast and thigh portions of the carcass. Control samples were redder in color compared to the treated samples during entire storage period.

The yellowness values (b*) substantially decreased during storage period and as concentrations of the chlorine dioxide increased. b* (yellowness) values were least affected by chlorine dioxide treatments in all the concentrations. b* values increased as storage period progressed. Almost similar colour values for control poultry carcass samples were reported by Allen *et al*., (1981) [1]. The above results were supported by Stivarius *et al*. (2002) [5] who conducted study on effect of chlorine dioxide treatment on beef trimmings and reported that ground beef from the chlorine dioxide treatment was (p<0.05) lighter (L*), less red, contained less oxymyoglobin but was not different (p>0.05) in yellowness (b*). This decrease in overall color might be due to the oxidation of myoglobin in the chlorine dioxide treated samples, thus causing slightly lower redness values (Stivarius *et al.*, 2002) [5]. Unda *et al*. (1989) [8] observed lower a* values in rib eye steak with 100 ppm of chlorine dioxide treatment.

Table 1: Effect of different levels of Chlorine dioxide on lightness (L*- value) in the colour of chicken carcass (Mean ± SE).

Portion of carcass	Treatments	0th day	3rd day	5th day	7th day
Breast	C	38.79±0.24^{aA}	39.01±0.24^{aA}	39.24±0.23^{aA}	39.43±0.24^{aA}
	T_1	39.94±0.33^{aA}	40.12±0.32^{bA}	40.35±0.32^{bA}	40.53±0.33^{bA}
	T_2	40.85±0.85^{bA}	41.32±0.25^{cA}	41.53±0.25^{cA}	41.74±0.24^{cA}
	T_3	41.96±0.22^{bA}	42.69±0.22^{dA}	42.89±0.22^{dA}	43.09±0.22^{dA}
Thigh	C	38.20±0.28^{aC}	38.80±0.31^{aB}	40.21±0.22^{aA}	42.55±0.23^{bA}
	T_1	38.34±0.28^{aC}	38.87±0.29^{aB}	40.22±0.19^{aA}	42.86±0.21^{bA}
	T_2	38.55±0.29^{aC}	39.49±0.26^{abB}	40.16±0.27^{aB}	41.33±0.16^{aA}
	T_3	39.72±0.23^{bC}	40.21±0.16^{bB}	40.83±0.18^{aAB}	41.73±0.27^{aA}

C: 0 ppm ClO_2, T_1: 50 ppm ClO_2, T_2: 75 ppm ClO_2, T_3: 100 ppm ClO_2.

$^{A-D}$ Means within a row, not sharing a common superscript (Uppercase), differ significantly (p<0.05) $^{a-d}$ Means within a column, not sharing a common superscript (lowercase), differ significantly (p<0.05)

Table 2: Effect of different levels of Chlorine dioxide on redness (a*- value) in the colour of chicken carcass (Mean ± SE).

Portion of carcass	Treatments	0th day	3rd day	5th day	7th day
Breast	C	4.24 ± 0.04^{cA}	4.10 ± 0.04^{cB}	3.94 ± 0.04^{aC}	3.74 ± 0.04^{dD}
	T_1	4.01 ± 0.03^{bA}	3.81 ± 0.04^{bB}	3.61 ± 0.03^{aC}	3.40 ± 0.03^{cD}
	T_2	3.94 ± 0.02^{bA}	3.73 ± 0.01^{bB}	3.52 ± 0.01^{aC}	3.32 ± 0.01^{bD}
	T_3	3.64 ± 0.02^{aA}	3.43 ± 0.01^{aAB}	3.31 ± 0.59^{bAB}	3.03 ± 0.01^{aB}
Thigh	C	6.73 ± 0.04^{aA}	6.51 ± 0.03^{cB}	6.32 ± 0.04^{bC}	5.74 ± 0.04^{dD}
	T_1	6.35 ± 0.10^{aA}	6.13 ± 0.09^{bA}	5.52 ± 0.16^{aB}	5.40 ± 0.03^{cB}
	T_2	6.23 ± 0.09^{aA}	5.93 ± 0.09^{abAB}	5.75 ± 0.09^{aBC}	5.32 ± 0.01^{bC}
	T_3	6.16 ± 0.58^{aA}	5.76 ± 0.10^{aA}	5.36 ± 0.27^{aAB}	5.03 ± 0.01^{aB}

C: 0 ppm ClO_2, T_1: 50 ppm ClO_2, T_2: 75 ppm ClO_2, T_3: 100 ppm ClO_2.
[A-D] Means within a row, not sharing a common superscript (Uppercase), differ significantly ($p<0.05$).
[a-d] Means within a column, not sharing a common superscript (lowercase), differ significantly ($p<0.05$)

Table 3: Effect of different levels of Chlorine dioxide on yellowness (b*- value) in the colour of chicken carcass (Mean ± SE).

Portion of carcass	Treatments	0th day	3rd day	5th day	7th day
Breast	C	24.18 ± 0.15^{aA}	24.00 ± 0.15^{aAB}	23.81 ± 0.15^{aAB}	23.62 ± 0.16^{aB}
	T_1	23.98 ± 0.14^{aA}	23.87 ± 0.15^{aB}	23.69 ± 0.17^{aC}	23.49 ± 0.17^{aD}
	T_2	23.92 ± 0.14^{aA}	23.82 ± 0.15^{aB}	23.64 ± 0.16^{aC}	23.44 ± 0.16^{aD}
	T_3	23.88 ± 0.14^{aA}	23.76 ± 0.15^{aAB}	23.56 ± 0.15^{aAB}	23.36 ± 0.15^{aB}
Thigh	C	15.73 ± 0.04^{bA}	15.50 ± 0.04^{cB}	15.31 ± 0.03^{bC}	15.12 ± 0.04^{bD}
	T_1	15.35 ± 0.10^{bA}	15.13 ± 0.09^{bcA}	14.53 ± 0.16^{aB}	14.21 ± 0.24^{aB}
	T_2	15.13 ± 0.09^{abA}	14.52 ± 0.16^{abA}	14.74 ± 0.10^{aA}	14.52 ± 0.08^{aB}
	T_3	14.96 ± 0.10^{aA}	14.91 ± 0.23^{aAB}	14.55 ± 0.10^{aB}	14.36 ± 0.10^{aB}

C: 0 ppm ClO_2, T_1: 50 ppm ClO_2, T_2: 75 ppm ClO_2, T_3: 100 ppm ClO_2.
[A-D] Means within a row, not sharing a common superscript (Uppercase), differ significantly ($p<0.05$)
[a-d] Means within a column, not sharing a common superscript (lowercase), differ significantly ($p<0.05$)

3.2 Sensory Evaluation

Sensory evaluation for both fresh meat and cooked meat were conducted and the scores were given for breast and thigh portions together.

3.2.1 Raw Chicken

The raw chicken colour score of control breast and thigh portions of carcass on the day of slaughter were higher than the chlorine dioxide treated samples i.e 3.60 in control and 3.40 in 50, 75 and 100 ppm treated samples respectively. The scores for control samples were consistently maintained during entire refrigeration storage, but in chlorine dioxide treated samples color scores dropped consistently during storage period The raw chicken color scores of control samples significantly ($p<0.05$) differed with samples treated with chlorine dioxide on 3rd, 5th, 7th days of refrigeration storage.

The raw chicken odour score of control and treated breast and thigh portions of carcass on the day of slaughter was similar i.e 4.00. Raw chicken odour scores obtained for 75 and 100 ppm treated samples were same on all the days of refrigeration storage. The odour scores of control samples consistently dropped during the storage, where as 50 ppm chlorine dioxide treated sample scores decreased after 5th day of storage whereas 75 and 100 ppm treated samples odour scores were consistent during entire storage period.

Table 4: Effect of different levels of Chlorine dioxide on sensory colour and odour of raw chicken meat (Mean ± SE).

Parameter	Treatments	0th day	3rd day	5th day	7th day
Colour	C	3.60 ± 0.24^{aA}	3.60 ± 0.24^{bA}	3.60 ± 0.24^{bA}	3.60 ± 0.24^{bA}
	T_1	3.40 ± 0.24^{aD}	3.00 ± 0.00^{aC}	2.40 ± 0.24^{aB}	2.00 ± 0.00^{aA}
	T_2	3.40 ± 0.24^{aD}	3.00 ± 0.00^{aC}	2.40 ± 0.24^{aB}	2.00 ± 0.00^{aA}
	T_3	3.40 ± 0.24^{aD}	3.00 ± 0.00^{aC}	2.40 ± 0.24^{aB}	2.00 ± 0.00^{aA}
Odour	C	4.00 ± 0.01^{aD}	3.00 ± 0.02^{aC}	2.00 ± 0.01^{aB}	1.00 ± 0.01^{aA}
	T_1	4.00 ± 0.01^{aC}	4.00 ± 0.01^{bC}	3.00 ± 0.02^{bB}	2.00 ± 0.00^{bA}
	T_2	4.00 ± 0.01^{aA}	4.00 ± 0.01^{bA}	4.00 ± 0.01^{cA}	4.00 ± 0.01^{cA}
	T_3	4.00 ± 0.01^{aA}	4.00 ± 0.01^{bA}	4.00 ± 0.01^{cA}	4.00 ± 0.01^{cA}

C: 0 ppm ClO_2, T_1: 50 ppm ClO_2, T_2: 75 ppm ClO_2, T_3: 100 ppm ClO_2.
[A-D] Means within a row, not sharing a common superscript (Uppercase), differ significantly ($p<0.05$)
[a-d] Means within a column, not sharing a common superscript (lowercase), differ significantly ($p<0.05$)
Colour score: 1 - discoloured, 2 - Slightly discoloured, 3 - Slightly pink, 4 - Moderately pink, 5 - pink.
Odour score: 1 - Extremely off-Odour, 2 - Moderately off-Odour, 3 - Slightly off Odour, 4 - No off-Odour.

3.2.2 Cooked Chicken

The colour score of control and treated samples was 7.00±0.00 on 0 day of storage and the colour scores did not change during entire days of storage. The colour scores in treated samples didn't change up to 5th day of storage but on the 7th day of refrigeration storage the colour score was decreased to 6.80±0.20, 6.60±0.24 and 6.40±0.24 in the samples treated with 50, 75 and 100 ppm respectively.

Cooked chicken flavour score of control and treated samples on 0th day were same i.e 7.00 and during the storage the cooked chicken flavour scores of control samples decreased from 7.00 to 6.40, 5.40 and 4.40 on 3rd, 5th and 7th days of refrigeration storage respectively. But 50 and 75 ppm cooked chicken samples flavour scores decreased from 5th day of refrigeration storage where as 100 ppm chlorine dioxide treated cooked samples the chicken flavour scores

consistently maintained during entire period.

Overall acceptability score of cooked meat samples i.e both control and chlorine dioxide treated samples on 0th day was 7.00 and in control sample the overall acceptability score decreased consistently throughout the storage but chlorine dioxide treated samples (50 & 75 ppm) decreased by 3rd day of storage, where as 100 ppm treated samples scores were unchanged during entire storage period.

The above results were supported by Stivarius *et al.,* (2002) [5] who concluded that chlorine dioxide had little effect on sensory color and odor characteristics. Similarly Zepeda *et al.* (1994) [10] found that vacuum packaged beef chucks treated with 200 ppm chlorine dioxide were higher in odor acceptability scores compared to control. They hypothesized that the decrease in off-flavor aromatic notes were caused by the ability of chlorine to dissipate these off-flavor compounds faster from treated meat surfaces, leaving no residual aroma.

Thiessen *et al.,* (1984) [7] also observed no off flavor aromas in broiler carcass at any level of residual $C1O_2$, which was similar to the present study.

Table 5: Effect of different levels of Chlorine dioxide on sensory colour, flavour and over all acceptability of cooked chicken (Mean ± SE).

Parameter	Treatments	0th day	3rd day	5th day	7th day
Colour	C	7.00±0.00	7.00±0.00	7.00±0.00	7.00±0.20
	T_1	7.00±0.00	7.00±0.00	7.00±0.00	6.80±0.20
	T_2	7.00±0.00	7.00±0.00	7.00±0.00	6.60±0.24
	T_3	7.00±0.00	7.00±0.00	7.00±0.00	6.40±0.24
Flavour	C	7.00 ± 0.00^{D}	6.40 ± 0.24^{bC}	5.40 ± 0.24^{bB}	4.40 ± 0.24^{bA}
	T_1	7.00 ± 0.00^{C}	7.00 ± 0.00^{aC}	5.60 ± 0.24^{bB}	4.60 ± 0.24^{bA}
	T_2	7.00 ± 0.00^{B}	7.00 ± 0.00^{aB}	6.80 ± 0.20^{aA}	6.60 ± 0.40^{aA}
	T_3	7.00±0.00	7.00 ± 0.00^{a}	7.00 ± 0.00^{a}	7.00 ± 0.00^{a}
Overall Acceptability	C	7.00 ± 0.00^{D}	6.40 ± 0.24^{bC}	5.40 ± 0.24^{bB}	4.40 ± 0.24^{bA}
	T_1	7.00 ± 0.00^{D}	7.00 ± 0.00^{aC}	5.60 ± 0.24^{bB}	4.60 ± 0.24^{bA}
	T_2	7.00 ± 0.00^{B}	7.00 ± 0.00^{aB}	6.80 ± 0.20^{aA}	6.60 ± 0.40^{aA}
	T_3	7.00 ± 0.00^{a}	7.00 ± 0.00^{a}	7.00 ± 0.00^{a}	7.00 ± 0.00^{a}

C: 0 ppm ClO_2, T_1: 50 ppm ClO_2, T_2: 75 ppm ClO_2, T_3: 100 ppm ClO_2.

(Scale: 8 point hedonic scale)

$^{A-D}$ Means within a row, not sharing a common superscript (Uppercase), differ significantly ($p<0.05$)

$^{a-d}$ Means within a column, not sharing a common superscript (lowercase), differ significantly ($p<0.05$)

4. Conclusion

From the present study, it was concluded that chlorine dioxide can be used in decontamination of poultry carcasses as it effectively retained the colour and sensory parameters of chicken meat under refrigerated storage and among the chlorine dioxide treated samples, 50, 75 and 100 ppm concentrations, 100 ppm of chlorine dioxide treatment showed much better results with acceptable quality of colour and various sensory attributes. Based on the results it may be concluded that 100 ppm of chlorine dioxide treated chicken carcasses could be safely stored for 7 days under aerobic packaging at refrigerated temperature (4±1 ºC) without any undesirable changes in organoleptic quality of chicken meat.

5. Acknowledgement

Authors acknowledge the Director, ICAR- National Research Centre on Meat, Hyderabad, India and Department of Livestock Products Technology, P V Narsimha Rao Telangana Veterinary University for providing necessary laboratory facilities to conduct this work.

6. References

1. Allen CE, Foegeding EA. Some lipid characteristics and interactions in muscle foods-a review. Food Technology; c1981.
2. Burfoot D, Mulvey E. Reducing microbial counts on chicken and turkey carcasses using lactic acid. Food control. 2011;22(11):1729-1735.
3. Duan D, Wang H, Xue S, Li M, Xu X. Application of disinfectant sprays after chilling to reduce the initial microbial load and extend the shelf-life of chilled chicken carcasses. Food control. 2017;75:70-77.
4. Lambert AD, Smith JP, Dodds Karen L. Shelf life extension and microbiological safety of fresh meat: A review. Food Microbiology. 1991;8:267-297.
5. Stivarius MR, Pohlman FW, McElyea KS, Apple JK. Microbial, instrumental color and sensory color and odor characteristics of ground beef produced from beef trimmings treated with ozone or chlorine dioxide. Meat Science. 2002;60(3):299-305.
6. SCVPH. Opinion of the Scientific Committee on Veterinary Measures relating to Public Health on the evaluation of antimicrobial treatments for poultry carcasses; c2003.
7. Thiessen GP, Usborne WR, Orr HL. The efficacy of chlorine dioxide in controlling Salmonella contamination and its effect on product quality of chicken broiler carcasses. Poultry science. 1984;63(4):647-653.
8. Unda JR, Molins RA, Zamojcin CA. Sanitization of Fresh Rib Eye Steaks with Chlorine Dioxide-Generating Binary Systems. Journal of Food Science. 1989;54(1):7-10.
9. USDA. Major world crop areas and climatic profiles; c2006. Available at: http://www.usda.gov/oce/weather/pubs/Other/MWCACP/index.htm (accessed 7 November 2007).
10. Zepeda CM, Kastner CL, Kenney PB, Campbell RE, Schwenke JR. Aroma profile of Subprimals from beef carcasses decontaminated with chlorine and lactic acid. J Food Prot. 1994a;57:674-8.
11. Zhu C, Chen Z, Yu G. Fungicidal mechanism of chlorine dioxide on Saccharomyces cerevisiae. Microbiol. 2013;63(2):495-502.