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Impact of various decontaminants on the physico-chemical properties of poultry meat

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Abstract

Background: Disinfection of carcasses plays a significant role in the overall decontamination of meat. During slaughter and processing, harmful bacteria like *E. coli*, *Salmonella*, *Campylobacter* and *Listeria* can contaminate the meat. If proper disinfection is not done, these pathogens can survive and spread through the food chain. This can lead to foodborne diseases and serious illness in humans. Therefore, effective carcass disinfection is essential to ensure meat safety and protect public health.

Methods: A study was undertaken to evaluate the different decontaminants like, water, chlorine (CL) 100 ppm and peroxyacetic acid (PAA) 50 ppm, on naturally contaminated chicken carcasses. The chicken carcasses were immersed in various decontaminant solutions for 5 minutes. After treatment, each group, along with the untreated control, was evaluated for various physiochemical parameters, including pH, Thio barbituric acid (TBA) value, and tyrosine content. A significant increase ($p \leq 0.01$) in the physiochemical parameters was observed as the storage period progressed from 0 to 9 days and 0 to 30 days in both the control and treated samples.

Results: From the present study, it was concluded that the application of peroxyacetic acid effectively lowered surface bacterial count on poultry carcass. It may be concluded from the results that a 50ppm peroxyacetic acid-treated carcass can be safely stored for 9 days at (4 ± 1 °C) and for 30 days under vacuum packaging at (-1.5 to -2.5 °C) without exhibiting undesirable quality changes.

Keywords: Peroxyacetic acid, chlorine, chilling, super chilling

Introduction

Over the past few decades, chicken meat has become more and more popular throughout the world. The nation produced 10.25 million tonnes of meat in total. About 48.96% of India's total meat production comes from poultry (BAHS, 2024). The primary factors driving up demand for poultry meat were its affordable prices, high nutritional content, and absence of religious taboos. Zoonotic infections like *Salmonella*, *Campylobacter*, *E. coli*, and *Listeria* can contaminate poultry carcasses during the slaughter process, resulting in human illness epidemics. Decontamination is the technique of removing, inactivating, or killing pathogens to make the environment clean and safe (Fraise et al., 2008; Godbey, 2014; MC Donnell, 2017) [10, 11, 17]. Physical methods, such as the application of hot water and steam. Antimicrobial agents, such as acetic acid, citric acid, hydrogen peroxide and chlorine have also been tested with various levels of success. As organic acids like acetic or lactic acid have good bactericidal activity and are generally regarded as safe (GRAS) additives, they have been used to sanitize carcasses Dickson et al. (1997) [9]. Surface decontamination of carcass with a novel decontaminant plays a pivotal role in improving meat quality and extending the shelf life. Recently, a combination of peroxyacetic acid and hydrogen peroxide has been tried as a potent decontaminant in the meat sector. Due to its excellent efficacy, nearly non-existent hazardous residues, easy application (in water solution), and reasonably low cost, peracetic acid is becoming a more commonly used antibacterial in a variety of industries relating to food and drinks. Peracetic acid combinations are permitted in the US Food and Drug Administration (FDA) approved as a sanitizer on food contact surfaces (21 CFR 178.1010) and meat, poultry and seafood (21 CFR 173.370), (Warburton Richard, 2014).

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Materials and Methods

Forty-eight broiler birds, aged 6 weeks and weighing between 1.25 to 1.5 kg, were sourced from the local market in Hyderabad and were slaughtered using a humane method (the birds were shackled and sent through an electrical water bath stunner set at 100 mA current and 50 volts for 5 seconds). The amount of current was monitored by an ammeter in the experimental abattoir of ICAR-National meat research institute (NMRI), Hyderabad. The carcass was split into two halves duly removing the skin. Then the visible fat and connective tissue residues were removed using a sterile, sharp stainless-steel knife. Four carcasses were subjected to treatment at a time without any dipping (Control), dipping in water (T₁), chlorine 100ppm (T₂) and peroxyacetic acid 50ppm (T₃) concentrations for about five minutes and drained off excess water. The breast meat was packaged in LDPE bags under vacuum and stored at 4±1°C. Analysis was done for chilled samples on 0, 3, 6 and 9 days of storage. For super chilled samples, the super chilling cabinet was maintained at -1.5±2.5 °C and the samples were analyzed on 0, 5, 10, 15, 20, 25, and 30 days. Four trials were conducted; samples were analysed for pH, Water Holding Capacity (WHC), Thiobarbituric Acid Value (TBA), Tyrosine parameters and data were analyzed.

Statistical Analysis

The data obtained from the experiment will be analyzed statistically as per the method outlined by (Snedecor and Cochran, 1995) method 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.).

Results and Discussion

pH

The pH value of the chicken meat in control samples increased significantly from day 0 (5.61±0.77) to day 9 (6.02±0.41), which was in agreement with Shivaji *et al.*, (2022) [24], who reported an increase in pH during the refrigerated storage of chicken meat. Similar findings were observed by Rathod *et al.*, (2022) [20], who reported that pH values increase significantly from day 0 to day 5 and from day 10 to day 20 during storage.

Under refrigeration storage of poultry meat, the pH value has been consistently observed to increase significantly, primarily due to the accumulation of metabolites, such as amines and ammonia, produced by microbial growth, particularly psychrotrophic bacteria (Shin *et al.* (2011) [23]. This effect is supported by a reported positive correlation between pH and total aerobic bacteria growth on fresh chicken carcass during storage at 4±1 °C Aksu *et al.* (2006) [2].

In the present study, treatment groups T₁ and T₃ experienced a significant ($p<0.05$) increase in pH values from day 0 to day 9, which aligns with findings from Bertram *et al.* (2019) [5], who reported increased pH in water and Peroxyacetic acid (PAA)-treated turkey breast fillets stored under refrigeration (4±1 °C) from day 1 to day 12. In the T₂ group, values increased significantly ($p<0.05$) from day 3 (5.58±0.08) to day 6 (5.58±0.08). Similar findings were reported by Shivaji *et al.*, (2022) [24], who observed an increase in the pH value of chlorine dioxide (100ppm) treated poultry carcass from day 0 to day 7 under refrigeration storage (4±1 °C).

Furthermore, samples from treatments T₂ and T₃ consistently exhibited significantly ($p<0.05$) lower pH values compared to the control (C) and T₁ samples on day 6 (5.82±0.10,

5.72±0.19, 5.97±0.31, 5.96±0.34) and day 9 (5.84±0.09, 5.80±0.09, 6.02±0.41, 6.02±0.18), respectively. These results are consistent with the experiment by Bertram *et al.*, (2019) [5], which examined the effect of water and PAA spray treatments on the microbial and sensory quality of turkey breast fillet stored under refrigeration.

Water Holding Capacity (WHC)

The Water Holding Capacity values in chicken meat samples during the chiller storage were depicted in the Figure 2. The values decreased significantly in control samples of chicken meat from day 0 (66.32±1.16) to day 9 (56.31±4.78), and the results were in accordance with studies of Kaale *et al.* (2014) [14], where, WHC of salmon breast fillet values decreased from day 1 to day 7 during chilled storage. According to Kondaiah *et al.* (1986) [16], the reduction in water holding capacity (WHC) during storage can be linked to the speed at which post-mortem pH falls, elevated ionic strength, protein denaturation, and increased water movement into the extracellular space.

In treatment T₁, the WHC values decreased significantly ($p<0.01$) from the 0th day to the 9th day. In T₂, T₃ WHC values did not decrease significantly, even up to the 9th day. The research work on the effect of contaminants on WHC could not be traced in the available literature.

THIO Barbituric Acid Value (TBA)

The TBA values of chicken meat samples during the chiller storage were depicted in the Figure 3. A significant increase in the TBA values in both control and T₁, T₂ samples was noticed from day 6 to day 9. Results regarding control were in agreement with Kaewthong *et al.* (2019) [15] study, which showed significant increase in TBA values of chicken breast meat sample from day 0 to day 8 during refrigeration storage. Vacuum packaged meat samples showed reduced TBA values as lipid oxidation slowed down in cold storage (Jouki and Khazaei, 2012) [13]. Results regarding water dipped broiler carcass were in agreement with Sonale *et al.* (2014) [26] study was a significant increase in TBA values of quail breast meat sample was observed from day 0 to day 15 during chilled storage. Results regarding 100ppm chlorine dioxide dipped broiler carcass were in accordance with Shivaji *et al.* (2022) [24] study, was TBARS values increased significantly from day 0 to day 7 during refrigeration storage. The TBARS results observed in (Tims and Watts, 1958) study were far less than the threshold level of (1-2 mg /malonaldehyde) in meat, and at this level, the sensory panel members were unable to detect the flavour. In treatment group T₃ also a significant increase was also observed from day 0 (0.011±0.02) to day 9 (0.040±0.05). However, the TBA values were within the limit of the threshold value. The research work on the effect of contaminants on TBA value could not be traced in the available literature. Amongst treatments the TBA values in T₃ and T₂ were significantly lower than control and T₁ samples on day 6 to day 9, respectively, during storage.

Tyrosine Value

The Tyrosine values of chicken meat samples during the chiller storage were presented in Figure 4. The results depicted that in control samples, a significant increase was observed from day 0 (1.73±0.04) to day 9 (7.06±0.08). In treatment groups T₁, T₂ and T₃ also a significant increase was noticed from day 0 (1.60±0.06, 1.18±0.03, 1.14±0.03) to day 9 (7.02±0.09, 5.07±0.06, 4.69±0.12) respectively. Results regarding water-dipped carcass were in agreement with

Sonale *et al.* (2014) [26], who reported that breast meat samples from quail also showed an increase in tyrosine values from day 0 to day 15 during frozen storage. Increase in the tyrosine values was attributed to autolytic changes in meat and bacterial action during the storage (Agnihotri, 1998; Dainty *et al.*, 1975; Strange *et al.*, 1977) [1, 7, 27]. Amongst the treatment groups, on day 0 onwards, the tyrosine values were significantly lower in T₃ (1.14±0.03) than in control (1.73±0.04) and T₁ (1.60±0.06) groups during storage. This indicated that PAA effectively controlled the proteolysis in the T₃ samples; however, the research work on the effect of contaminants on tyrosine values could not be traced in the available literature.

Physico-chemical properties in super chilled storage pH

The pH values of chicken meat samples during superchilled storage are depicted in Figure 5. Control samples exhibited a significant increase in pH from day 0 (5.61±0.77) to day 30 (6.26±0.05), consistent with findings by Kaewthong *et al.*, (2019) [15], who reported increased pH in chicken breast meat stored at -1.5 to -2.5 °C over 28 days.

The increase in pH can be attributed to different factors over time. Initially (days 0-10), the rise in pH could result from the accumulation of inorganic phosphoric acid following the depletion of muscle adenosine triphosphate, as reported by Scherer *et al.*, (2006) [21] in grass carp. Subsequent increases in pH (days 15-20) are likely due to the production of ammonia, amines, and other substances resulting from protein denaturation caused by microbial activity and endogenous enzymes, a mechanism described by Muela *et al.*, (2010) [18] in lamb. Generally, the increase in pH during storage is associated with enzymatic protein breakdown and microbial activity.

In the treatment groups, T₁ and T₂ samples showed a significant increase in pH from day 0 to day 30. T₃ samples maintained stable pH values up to day 20, but then increased significantly between day 20 and day 30.

Across the treatments, T₃ and T₂ samples consistently maintained significantly lower pH values compared to the control (C) and T₁ samples from day 15 to day 30. Notably, on days 20 and 30, the differences in pH values among all treatments were statistically significant.

Water Holding Capacity (WHC)

The Water Holding Capacity values for chicken meat samples stored in the chiller are depicted in Figure 6. The WHC levels of chicken meat in control samples significantly decreased ($p<0.01$) from the 10th day (64.35±1.09) to the 30th day (51.74±1.73). Our control values differed from those reported by Kaale *et al.*, (2013), who found a substantial decrease ($p<0.01$) in WHC of Atlantic salmon fillets from the first day to 21st days of ultra-cold storage.

The current study's findings were consistent with those of Kondaiah *et al.*, (1986) [16], who claimed that the decrease in WHC during storage could be ascribed to the rate of postmortem pH fall, elevated ionic strength and protein denaturation, and increased transport of water into extracellular spaces. WHC readings in treatment group T₁ fell significantly from day 0 to day 5 and from day 20 to day 30.

The WHC levels in the T₂ sample fell considerably from day 0 to day 5 and from day 15 to day 30 (65.08±1.49) and 62.08±0.86, respectively.

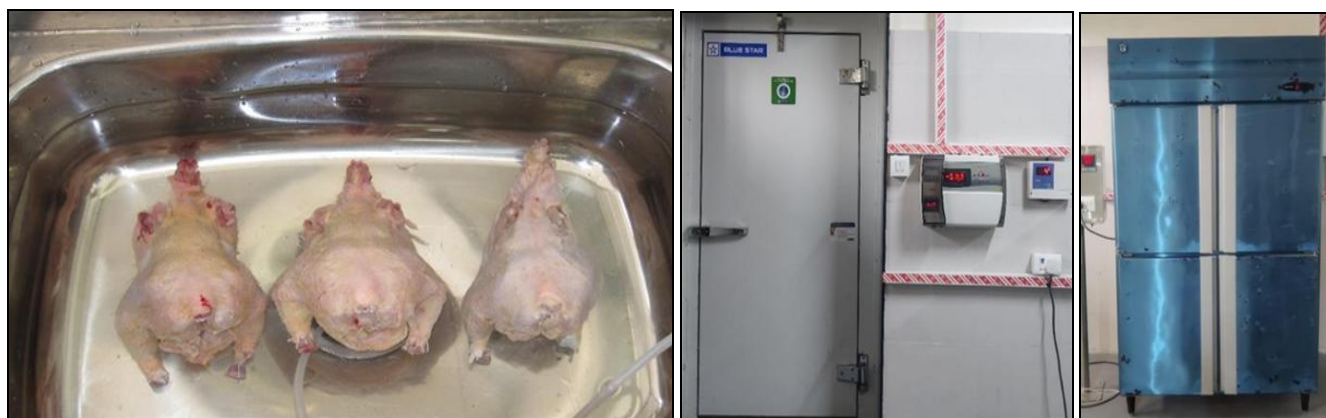
There were no significant differences in the T₃ group during storage. Amongst the treatments on the 25th day, WHC values were significantly higher in T₃ (64.25±1.11), T₂ (62.86±1.16) than in control (67.62±1.79) and T₁ (57.83±1.48). There is a significant reduction in WHC of super-chilled meat, indicating a severe effect of denaturation of muscle proteins at -2±0.5°C reported by (Dunn and Rustard, 2007) in super-chilled cod fillets.

Thiobarbituric Acid Value (TBA)

The TBA values for chicken meat samples during storage in the chiller are depicted in Figure 7. There was a significant increase in the TBA values for both the control and T₁, T₂ and T₃ samples from the 25th day to the 30th day. Our findings for the control values align with those of Chen *et al.*, (2020), who found that the TBARS values of vacuum-packed beef cuts significantly decreased ($p<0.05$) from day 0 to day 20 during storage at super-chilled temperatures (-1.5 to -2.5 °C). In the treatments, the TBA values for T₃ and T₂ were significantly lower than those of the control and T₁ samples between the 25th and 30th days of storage. The findings of this study concerning TBA values align with Sen (1996), who noted that TBA values increase during the entire storage duration, which could be attributed to the oxygen permeability of the packaging material. Additionally, Strange *et al.*, (1977) [27] suggested that lipid oxidation in the meat could be a contributing factor. The TBA values experienced a substantial rise ($p<0.05$) over the storage period, which may be attributed to the onset of lipid oxidation as reported by Benjakul and Bauer (2001) [4]. They also indicated that the formation of ice crystals leads to damage in muscle tissue, resulting in the release of pro-oxidants that promote lipid oxidation.

TYROSINE Value

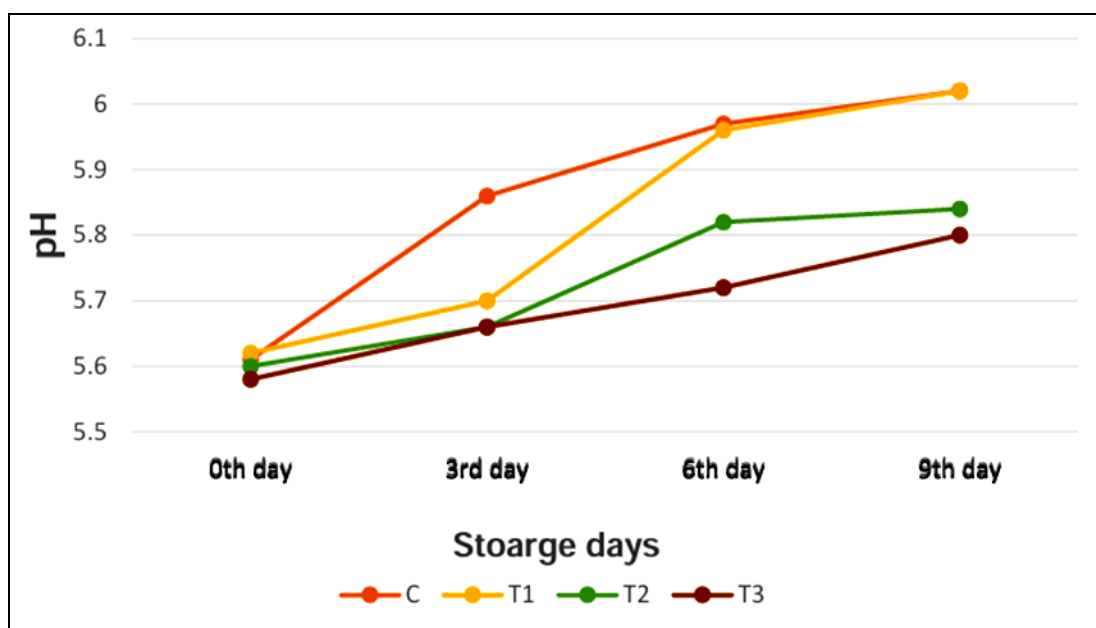
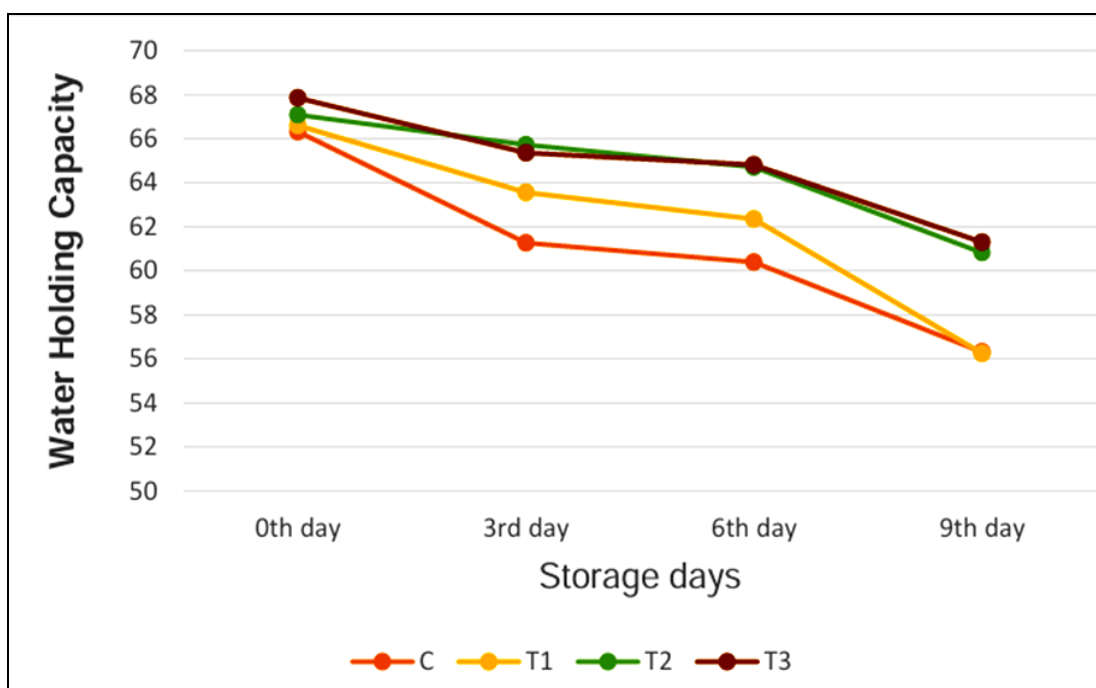
The Tyrosine values of chicken meat samples stored in the chiller are depicted in Figure 8. The tyrosine values for both control and T₁ samples exhibited a significant increase from day 0 (1.73±0.04, 1.60±0.06) to day 30 (5.27±0.24, 5.20±0.24), respectively. These findings regarding the control values were consistent with the results of Rathod *et al.* (2022) [20], who indicated that the tyrosine values in vacuum-packed broiler meat decreased significantly from day 0 to day 20 during super-chilled storage at temperatures ranging from -1.5 to -2.5 °C. In treatment group T₂ the tyrosine values increased significantly from day 10 (3.20±0.06) to day 20 (4.07±0.05) and day 30 (5.20±0.04), respectively. Amongst the treatment groups, on the 20th day and 30th day the tyrosine values were significantly lower in T₃ than control and T₁, T₂ groups during storage. These findings were in agreement with (Agnihotri., 1998; Dainty *et al.*, 1975; Strange *et al.*, 1977) [1, 7, 27] who reported that an increase in tyrosine values during the entire storage period could be due to autolytic changes in meat and bacterial action. According to Muela *et al.* (2010) [18], the rise in tyrosine levels during storage could be attributed to protein degradation caused by bacteria associated with meat spoilage by intrinsic enzymes.



Decontaminant dipped broiler carcass

Chiller storage

Super chiller storage

Fig 1: Effect of different decontaminants on pH (Mean $\pm$ SE) of chicken meat during chiller storage ($4\pm 1^\circ\text{C}$)**Fig 2:** Effect of different decontaminants on water holding capacity (%) (Mean $\pm$ SE) of chicken meat during chiller storage ($4\pm 1^\circ\text{C}$)**Fig 3:** Effect of different levels of decontaminants on thiobarbituric acid value (mg malonaldehyde/kg) (Mean $\pm$ SE) of chicken meat during chiller storage ($4\pm 1^\circ\text{C}$)

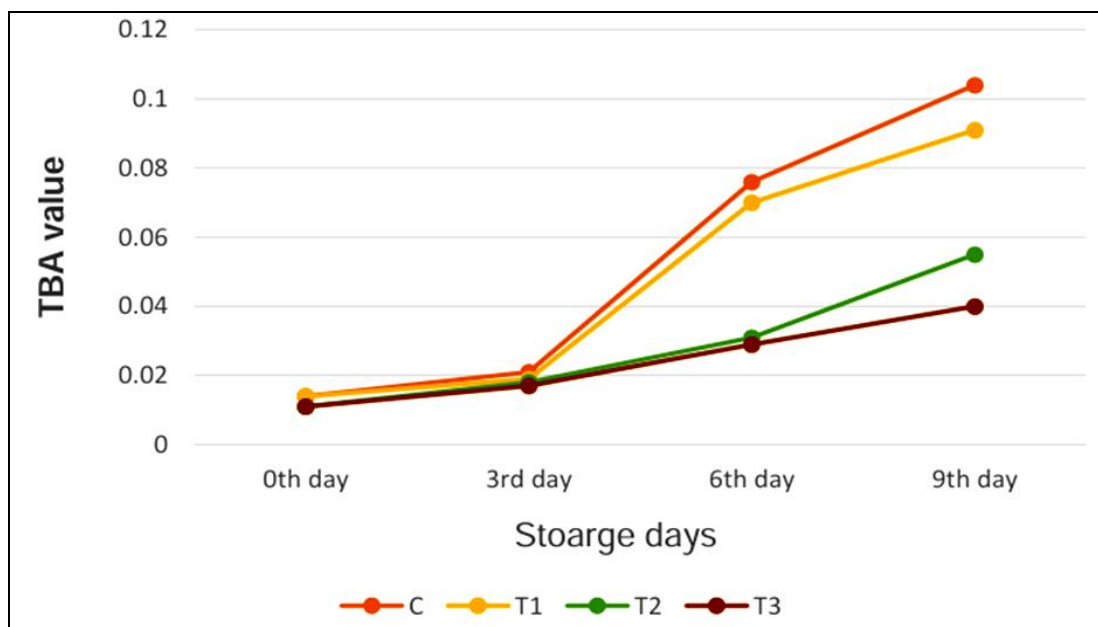


Fig 4: Effect of different decontaminants on tyrosine value (mg /100 gm) (Mean $\pm$ SE) of chicken meat during chiller storage (4 $\pm$ 1°C)

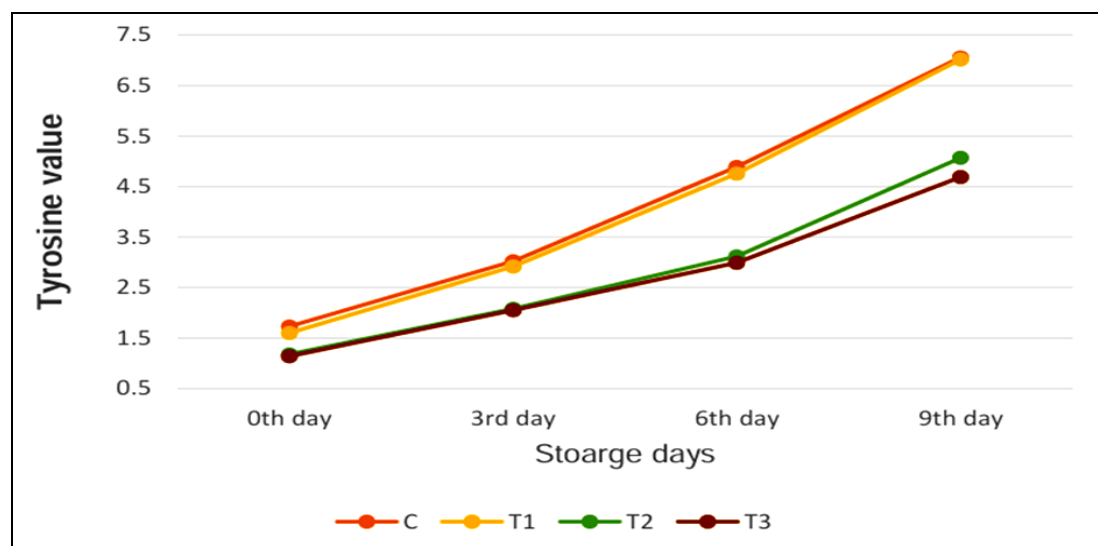


Fig 5: Effect of different decontaminants on pH (Mean $\pm$ SE) of chicken meat during super chilled storage (-1.5 $\pm$ 2.5°C)

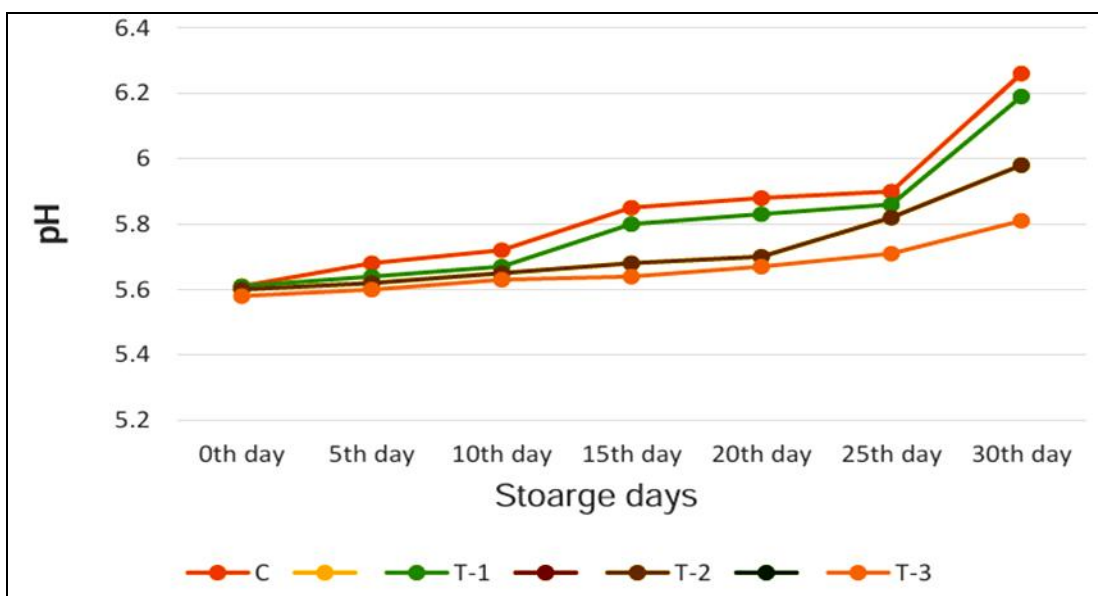


Fig 6: Effect of different decontaminants on water holding capacity (%) (Mean $\pm$ SE) of chicken meat during super-chilled storage (-1.5 $\pm$ 2.5°C)

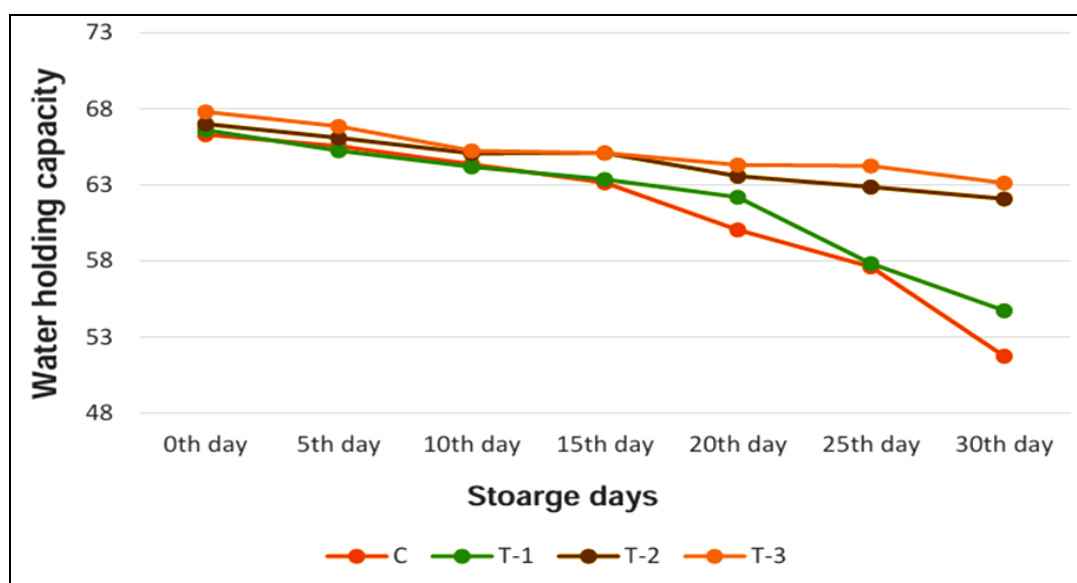


Fig 7: Effect of different decontaminants on thiobarbituric acid value (mg malonaldehyde / kg) (Mean $\pm$ SE) of chicken meat during super-chilled storage ($-1.5 \pm -2.5^\circ\text{C}$)

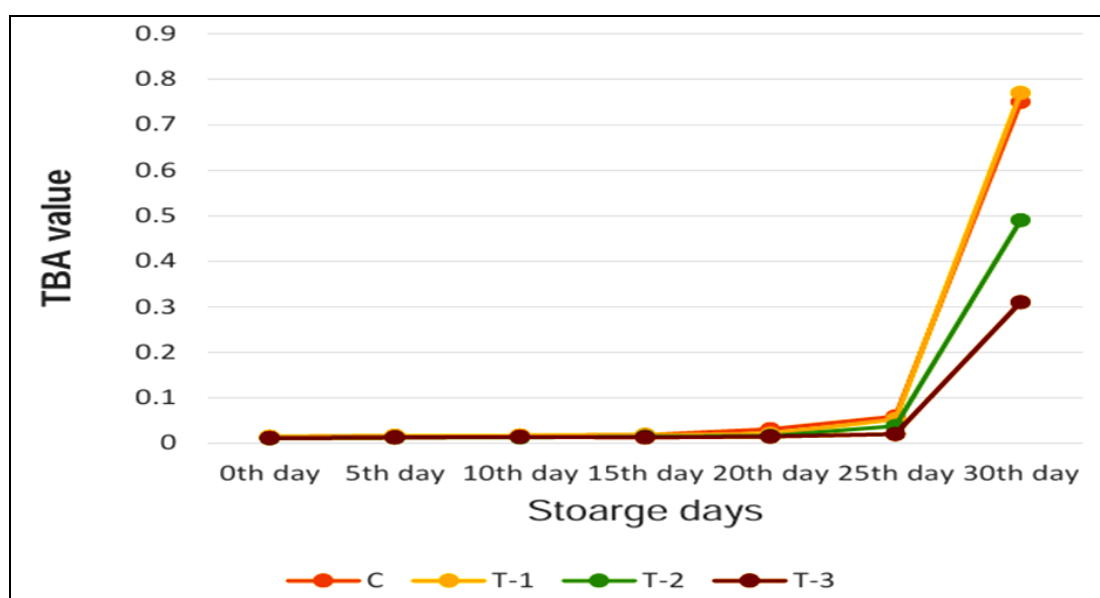


Fig 8: Effect of different decontaminants on tyrosine value (mg/100gm) (Mean $\pm$ SE) of chicken meat during super-chilled storage ($1.5 \pm -2.5^\circ\text{C}$)

Conclusion

The current study found that broiler meat treated with peroxyacetic acid retained a low pH and freshness, thus preserving its quality and extending its shelf life to 9 days in chiller storage and 30 days in super chiller storage. In comparison, with other decontaminants like chlorine, extended shelf life up to 6 days in chiller storage and 25 days in super chiller storage, while water resulted in 6 days in chiller and 20 days in super chiller storage. Control samples had an even shorter shelf life, lasting only 3 days in the chiller and 15 days in the super chiller storage.

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Conflict of Interest

The authors declares that they have no conflict of interest.

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Not available

Reference

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