



Effects of Modified Atmospheric Packaging on Ground Chicken Color and Lipid Oxidation

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Abstract: The objective of the current study was to evaluate the color changes and lipid oxidation of ground chicken patties packaged in polyvinyl chloride (PVC) film, high-oxygen (HiOx)-modified atmospheric packaging (MAP; 80% oxygen + 20% carbon dioxide [CO₂]), and carbon monoxide (CO)-MAP (0.4% CO + 19.6% CO₂ + 80% nitrogen) and stored at 2°C. Surface color was measured using a HunterLab MiniScan spectrophotometer on days 0, 1, 2, and 4. Lipid oxidation, pH, and aerobic plate count were determined on days 0 and 4 of storage. Fatty acid profiles were determined on day 0 to characterize saturated and unsaturated fatty acids. Patties packaged in PVC had greater ($P < 0.05$) pH than HiOx-MAP and CO-MAP. Gas chromatography analysis indicated that ground chicken has 72.8% unsaturated fatty acids and 27.2% saturated fatty acids (based on total lipids and fatty acid methyl ester). The formation of carboxymyoglobin on ground chicken patty surface was confirmed by peaks at 420 and 570 nm, whereas oxymyoglobin had peaks at 410 and 580 nm. Instrumental color analysis indicated both HiOx-MAP and CO-MAP had greater ($P < 0.05$) redness (a^* values) than PVC on day 4 of storage. Patties packaged in HiOx-MAP had greater ($P < 0.05$) chroma values than CO-MAP and PVC on day 4 of storage. Visual panelists noted less ($P < 0.05$) surface discoloration in CO-MAP than PVC and HiOx-MAP on day 4 of storage. Lipid oxidation was greater ($P < 0.05$) in PVC and HiOx-MAP than CO-MAP. CO inclusion at 0.4% level effectively inhibited lipid oxidation and stabilized surface redness during refrigerated storage of ground chicken.

Key words: ground chicken, modified atmospheric packaging, carbon monoxide, color, lipid oxidation, meat color

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Introduction

Consumers utilize visual appearance to assess wholesomeness and freshness of muscle foods. Although chicken has lower myoglobin content than beef or pork, visual perception is relevant in evaluating the quality of ground chicken. Ground meat is more susceptible to oxidation because oxygen (O₂) is incorporated during the mixing of the fat and lean tissue (Faustman et al., 2010; Zareian et al., 2019; Hoa et al., 2021). Therefore, ground meats' shelf life must be optimized to limit quality deterioration (Saucier et al., 2000). In the United States, 94% of poultry is sold as case-ready meat. The

adoption of case-ready meat has allowed processors to modify the gas composition within a package to improve appearance and shelf life. Chicken meat is more prone to lipid oxidation owing to greater unsaturated lipid content within phospholipid membrane than beef and pork (Rhee et al., 1996). Therefore, low- or no-O₂ packages that limit lipid oxidation and maintain ground chicken's pink color are important to meet consumer expectations and limit meat waste.

The poultry industry utilizes high-oxygen (HiOx)-modified atmospheric packaging (MAP) (70% to 80% O₂ and remaining carbon dioxide [CO₂]) to promote appearance. However, greater O₂ concentration accelerates lipid oxidation, off-flavor development, and

premature browning in cooked meat (John et al., 2005; Suman et al., 2009; Djimsa et al., 2017). The use of carbon monoxide (CO) was approved by the US Food and Drug Administration in 2002 at a level of 0.4% in MAP gas mixture to improve color and shelf life of meat (Cornforth and Hunt, 2008; Van Rooyen et al., 2017). CO can bind with the porphyrin ring of myoglobin and results in the formation of carboxymyoglobin, which gives a stable red color to meat (Sørheim et al., 1997). CO-MAP is used in the beef industry during the transportation of meat in mother bags to create anaerobic conditions and maintains acceptable consumer color and shelf life. In addition, when used along with other gases such as CO, nitrogen (N₂), and CO₂, meat has better flavor acceptability, no bone darkening, no premature browning during cooking, and improved tenderness (John et al., 2005; Cornforth and Hunt, 2008; Suman et al., 2011; Denzer et al., 2020; Cassens et al., 2021).

Fraqueza and Barreto (2011) reported a shelf life of 25 d for turkey fillets stored at 0°C under MAP consisting of 0.5% CO, 80% CO₂, and 19.5% N₂ relative to 5 d of shelf life for aerobically packaged meat. These researchers have demonstrated that the inclusion of CO along with anoxic gas mixtures for turkey meat under MAP imparted bright pink color preferred by consumers without leading to the appearance of undercooked meat. However, unlike in beef (Uboldi et al., 2015) and pork (Krause et al., 2003), the protective antioxidant effect of anaerobic MAP with CO was not observed in turkey breast muscles after 12 d of storage (Fraqueza and Barreto, 2011). The use of turkey breast muscles, which are lower in lipid and myoglobin content, may have contributed to the lack of effect on lipid oxidation with CO-MAP compared with other MAP.

Even though the beneficial effects of CO-MAP in enhancing the quality and shelf life of different red meats have been studied, its effect in poultry meat, especially ground chicken, has not been reported in the literature. Therefore, the objective of the current research was to evaluate quality attributes of ground chicken under aerobic conditions (polyvinyl chloride [PVC]), HiOx-MAP (80% O₂ + 20% CO₂), and CO-MAP (0.4% CO + 19.6% CO₂ + 80% N₂).

Materials and Methods

Preparation and storage of ground chicken patties

All procedures were approved by the Oklahoma State University Institutional Animal Care and Use

Committee. Day-old male Cobb × Cobb broiler chick strain was obtained from a commercial hatchery (Siloam Springs, AR) and raised to 42 d at the Oklahoma State University Poultry Facility. Fifty live birds weighing approximately 3.0 kg live weight each were slaughtered according to standard procedures at the Department of Animal and Food Sciences, Oklahoma State University slaughter facility. The dressed broiler carcasses were chilled overnight and deboned. Thighs from 10 birds were pooled together to form one batch. Thighs from the remaining birds were pooled to form, in total, 5 batches (50 birds ÷ 10-bird pools = 5 batches or 5 replications). Pooled thighs from 10 birds were ground through a 4.8-mm plate of a meat mincer, which resulted in a batch of 2 kg. The batches were then reground to ensure a finely ground product. From each batch, 12 patties (100 g, 10-cm diameter, and 1.5-cm thickness; 12 patties × 5 batches = 60 total patties) were formed manually. Of the 12 patties formed, 6 were assigned to day 0 analysis, and 6 were assigned to day 4 analysis. Of the 6 patties assigned to each day, 2 patties were assigned to each of the 3 packaging systems: aerobic packaging (PVC), HiOx-MAP (80% O₂ + 20% CO₂), and CO-MAP (0.4% CO + 19.6% CO₂ + 80% N₂). The first patty from each packaging treatment was used to determine day 0 aerobic plate count, and the second patty was used to measure color, pH, and lipid oxidation on day 4 of storage.

Patties assigned to aerobic packaging (PVC) were placed individually on Styrofoam trays with soaker pads and overwrapped with O₂-permeable PVC fresh meat film (15,500 to 16,275 cm³ O₂/m²/24 h at 23°C; E-Z Wrap Crystal Clear Polyvinyl Chloride Wrapping Film). Patties designated for HiOx-MAP and CO-MAP were placed individually on plastic rigid trays with soaker pads and packaged with a Koch MultiVac 500 (Bunzl Koch Supplies, Kansas City, MO) using Prime Source pouches (impermeable to O₂, 4 mil; Bunzl Koch Supplies) and certified gas blends (Stillwater Steel and Welding Supply, Stillwater, OK) After packaging, patties were placed on a coffin-style open display case maintained at 2°C ± 1°C under continuous lighting (1,612 to 2,152 lx; Philips Delux Warm White Fluorescent lamps, Somerset, NJ; color rendering index = 86; color temperature = 3,000 K). All packages were rotated daily to minimize differences in light intensity or temperature caused by location. A headspace gas analyzer (Model 6600 Headspace Oxygen–Carbon Dioxide Analyzer, Illinois Instruments, Ingleside, IL) was utilized to ensure the desired O₂ and CO concentration within MAP systems.

pH

pH was measured on days 0 and 4 of storage. Triplicate 5-g samples of ground chicken from each package were homogenized with 50 mL of deionized water using a Polytron PT 10-35 homogenizer (Kinematica, Luzernerstrasse, Switzerland), and the pH of the homogenate was measured using an Accumet 50 pH meter (Fisher Scientific, Fair Lawn, NJ).

Instrumental color evaluation and characterizing the formation of carboxymyoglobin

Surface color was measured days 0, 1, 2, and 4 repeatedly on patties assigned to 4 d of storage. Precautions described in the American Meat Science Association (AMSA) Meat Color Guide were taken when measuring the surface color of patties packaged in HiOx-MAP and CO-MAP (AMSA, 2012). More specifically, the packages were inverted to allow the ground chicken patties to contact film surface, and care was taken to minimize moisture and/or fat smearing on the film surface (page 51; AMSA, 2012). Commission Internationale de l'Éclairage (CIE) L^* (lightness), a^* (redness), and b^* (yellowness) values (CIE, 1976) and reflectance spectra (from 400 to 700 nm in 10 nm increments) were measured at 3 random locations on each patty using a HunterLab MiniScan XE Plus colorimeter (HunterLab Associates, Reston, VA) with illuminant A, 2.54-cm-diameter aperture, and 10° standard observer. The CIE a^* and b^* values were also used to calculate chroma $(a^{*2} + b^{*2})^{1/2}$. The reflectance and absorbance spectra from 400 to 700 nm were also used to characterize carboxymyoglobin formation. Absorbance was calculated using reflectance values from 400 to 700 nm using the equation $A = (2 - \log R)$, where A represents absorbance and R represents percentage reflectance (Ramanathan et al., 2010; AMSA, 2012). The line smoothing feature in Microsoft Excel was used to smooth absorbance spectra.

Visual color evaluation

A trained panel ($n = 6$) conducted visual color evaluations on days 0, 2, and 4. The panelists repeatedly evaluated color on patties assigned to day 4 of storage. All panelists passed the Farnsworth-Munsell 85-hue test. Panelists were selected and trained according to AMSA (1991) guidelines. Panelists scored each ground chicken to assess muscle color using an 8-point scale (1 = pale pinkish-gray, 2 = slightly pale pinkish-gray, 3 = moderately light pinkish-gray, 4 = grayish-

pink, 5 = slightly dark grayish-pink, 6 = moderately dark grayish-pink, 7 = dark grayish-pink, and 8 = very dark grayish-pink) and discoloration using a 6-point scale (1 = no discoloration, 0%; 2 = slight discoloration, 1% to 20%; 3 = small discoloration, 21% to 40%; 4 = modest discoloration, 41% to 60%; 5 = moderate discoloration, 61% to 80%; and 6 = extensive discoloration, 81% to 100%).

Proximate composition and fatty acid profiling

Both proximate composition and fatty acid profiling were conducted to characterize ground chicken. Proximate and fatty acid profiling was only conducted on day 0 of storage ($n = 5$ replications).

Proximate composition. Approximately 200 g of ground chicken meat collected from each batch was placed on a sampling plate, and proximate analysis was determined using an AOAC-approved (Official Method 2007.04) near-infrared spectrophotometer (FOSS Food Scan 78800; Dedicated Analytical Solutions, DK-3400, Hillerod, Denmark). Compositional values were reported on a percentage basis (English et al., 2016).

Fatty acid profiling. A 50-g sample from each batch was utilized to characterize the fatty acid composition of ground chicken using gas chromatography (Sharma et al., 2021). Fat was transmethylated, and the fatty acid methyl esters were analyzed by gas chromatography equipped with a flame ionization dissociation detector (Agilent Technologies, Wilmington, DE). The fatty acid methyl esters were introduced onto a Supelco SP 2560 (100 × 0.25 mm inner diameter, 0.20-mm film thickness) column (Supelco Inc., Bellefonte, PA) using a split injector set at 230°C with a 1:100 split ratio. Helium was the carrier gas at 1 mL min⁻¹, and the gas chromatograph program was as follows: initial temperature 150°C for 1 min, increase 1°C min⁻¹ to 165°C, hold 1 min; increase 0.2°C min⁻¹ to 167°C followed by a linear ramp of 1.5°C min⁻¹ to 225°C and hold for 5 min. A flame ionization detector (Agilent Technologies) operating at 250°C was used, and peak areas were recorded by Chemstation software. Fatty acid methyl esters were identified by comparison of retention times with internal standards purchased (Nu-Chek Prep Inc., Elysian, MN). The data obtained by fatty acid profiles of ground chicken samples were used to calculate polyunsaturated fatty acids, monounsaturated fatty acids, total saturated fatty acids, n-6 fatty acids, and n-3 fatty acids. The results were

reported on a percentage basis (based on total lipids and corresponding fatty acid methyl ester).

Lipid oxidation

Thiobarbituric acid reactive substance (TBARS) values were measured on days 0 and 4 of storage (Witte et al., 1970; Wills et al., 2017). Five-gram samples in triplicate from interior and exterior were mixed with 20% trichloroacetic acid, homogenized in a blender, and filtered using Whatman No. 1 filter paper. One milliliter of filtrate was mixed with 1 mL of 20 mM thiobarbituric acid and was incubated at 25°C for 20 h. The absorbance of samples measured spectrophotometrically (Shimadzu UV-2401 PC spectrophotometer; Shimadzu Inc., Columbia, MD) at 532 nm was reported as TBARS values. The lipid oxidation values were reported as milligrams of malondialdehyde per kilogram of meat (Section XI, AMSA, 2012).

Aerobic plate count

A 25-g ground chicken sample was collected on days 0 and 4 of storage and transferred to a sampling bag (B11582; Whirl-Pak, Madison, WI) using a sterile spatula. Each ground chicken sample was mixed with 250 mL 0.1% peptone water and stomached at 230 RPM for 1 min in the sampling bag using a lab blender (Seward Stomacher Model 400; West Sussex, UK). One milliliter of sample from each bag was serially diluted, and the appropriate dilutions were plated on 3M Petrifilm rapid aerobic count plates as per the manufacturer's recommendation.

Statistical analysis

The experimental design was a randomized block. Each batch served as a block. The treatments include packaging type (PVC, HiOx-MAP, or CO-MAP) and storage time. The repeated option in PROC MIXED was used to assess the covariance-variance structure among the repeated measures for display color data. The most appropriate structure was determined using Akaike's information criterion output. Type-3 fixed effects of packaging type, storage time, and their interactions were analyzed using the Mixed Procedure of SAS version 9.4 (SAS Institute Inc., Cary, NC). In trained panel analysis, the panelist was used as the random effect. For all analyses, when a significant F-test was identified ($P < 0.05$), least-squares means were separated using a pairwise t test (PDIF option).

Results and Discussion

pH and total plate count

There was a packaging effect for pH ($P < 0.05$; Figure 1). Storage time had no effect on ground chicken patties' pH. Ground chicken patties in HiOx-MAP and CO-MAP had lower pH than patties in PVC package. However, no difference ($P > 0.05$) in pH was observed between HiOx-MAP and CO-MAP samples. The pH of the ground chicken ranged from 5.97 to 6.06, which is characteristic of normal poultry meat (Saucier et al., 2000; Byron et al., 2020; Zhang et al., 2021). Lower pH in HiOx-MAP and CO-MAP samples might be due to the dissolution of CO₂ into the aqueous phase of meat, resulting in carbonic acid and associated pH reduction (Fernández-López et al., 2008). No difference in pH of beef steaks packed in 0.1%, 0.3%, and 0.5% CO-MAP was observed relative to vacuum or aerobically packaged steaks during storage at 2°C (Sakowska et al., 2016).

The main effect of storage time was significant for aerobic plate count ($P < 0.05$; day 0 = 4.2 colony-forming units [cfu]/mL and day 4 = 6.4 cfu/mL). In the current study, packaging type had no significant effect on aerobic plate count. Previous research noted that low O₂ conditions decreased microbial growth (Baker et al., 1985).

Proximate composition and fatty acid profiles

The ground chicken had 72.01% ± 0.5% moisture, 21.92% ± 0.2% protein, and 4.37% ± 0.02% fat (least-squares means ± standard error). Ground chicken had

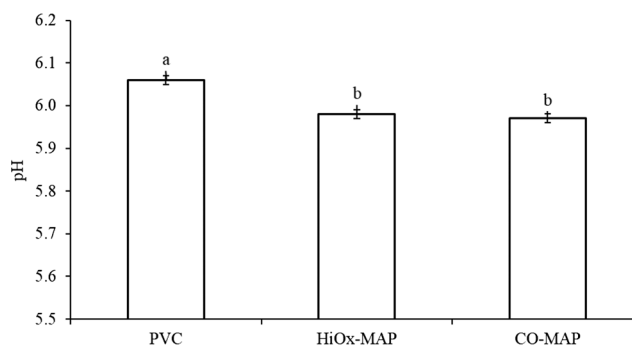


Figure 1. Effects of MAP on ground chicken pH values. PVC packaging; HiOx-MAP = 80% O₂ + 20% CO₂; CO-MAP = 0.4% CO + 19.6% CO₂ + 80% N₂. Least-squares means with different letters (a, b) are different ($P < 0.05$). pH readings were taken on days 0 and 4. Only packaging effect was significant. Storage time had no effect on pH. Number of replications = 5; 5 replications × 3 packaging × 2 storage time points = 30 observations. CO = carbon monoxide; HiOx = high-oxygen; MAP = modified atmospheric packaging; PVC = polyvinyl chloride.

27.2% saturated fatty acids and 72.8% unsaturated fatty acids. Previous research reported that chicken has more unsaturated fatty acids than beef and pork (Rhee et al., 1996).

Instrumental color

There was a significant packaging \times storage time interaction that resulted for a^* values, chroma, muscle color, and discoloration scores. There was no packaging or storage time main effect ($P = 0.52$) that resulted for L^* values (average L^* PVC = 56.7, HiOx-MAP = 56.9, CO-MAP = 56.1, standard error = 0.5).

Chicken is classified as white meat owing to its relatively lower myoglobin content compared with beef or pork. Saturation of myoglobin with O_2 or CO can impart a light-pink color. Limited published research has determined the effects of CO on ground chicken color. The formation of carboxymyoglobin was confirmed by observing changes in characteristic peaks in absorption spectra. Both oxymyoglobin and carboxymyoglobin can impart similar meat color. However, there are differences in absorption peaks between carboxymyoglobin and oxymyoglobin. In the current research, carboxymyoglobin has peaks at 420 (Soret

peak) and 570 nm, whereas oxymyoglobin has peaks at 410 and 580 nm (Figure 2). Similar absorption peaks were reported in broiler chicken by Sackett et al. (1986) when CO was present in the preslaughter environment.

On day 0 of storage, PVC packaged patties had greater a^* values than CO-MAP (Figure 3). Carboxymyoglobin is formed by binding CO to deoxymyoglobin. Oxymyoglobin is often formed during processing; therefore, the conversion of oxymyoglobin to deoxymyoglobin is required for the formation of carboxymyoglobin. Depending on meat conditions, a period of approximately 24 to 48 h is required to develop carboxymyoglobin. Therefore, chroma values were lower in CO-MAP than PVC packaging on day 0 of storage. On day 4, both HiOx-MAP and CO-MAP had greater redness than PVC packaging. In support, visual panelists also noted minimal changes in surface discoloration scores in CO-MAP and HiOx-MAP compared with PVC during 4 d of storage (Figure 4). Furthermore, changes in lean color scores were more noticed during 4 d of storage in PVC than CO-MAP and HiOx-MAP. Previous studies also noted improved redness of ground chicken in HiOx-MAP (Saucier et al., 2000; Seydim et al., 2006; Keokammerd et al., 2008; Latou et al., 2014).

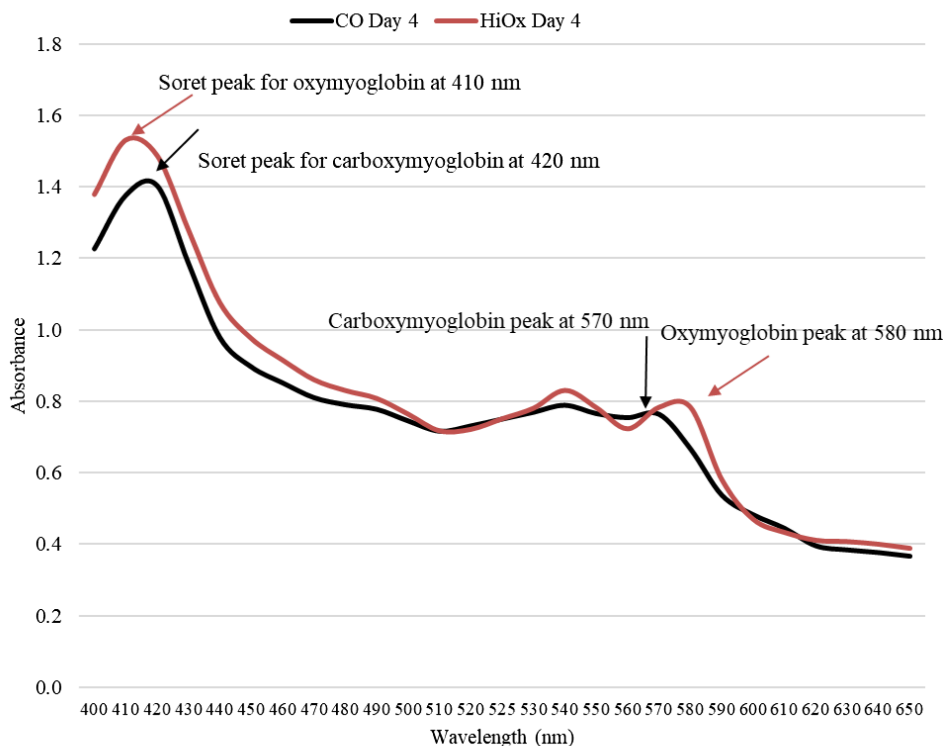


Figure 2. Changes in absorbance spectra between carboxymyoglobin and oxymyoglobin forms. Surface reflectance values from 400 to 700 nm were taken on patties packaged in CO-MAP and HiOx-MAP on day 4 of storage. The reflectance values were converted to absorbance values by using the equation $A = (2 - \log R)$, where A represents absorbance and R represents percentage reflectance. HiOx-MAP = 80% O_2 + 20% CO_2 ; CO-MAP = 0.4% CO + 19.6% CO_2 + 80% N_2 . CO = carbon monoxide; HiOx = high-oxygen; MAP = modified atmospheric packaging.

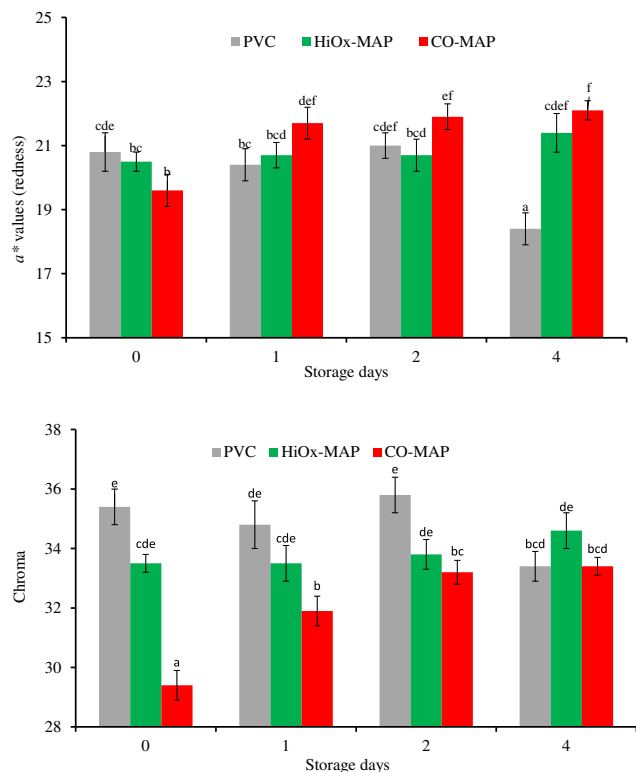


Figure 3. Effects of MAP and storage time on ground chicken redness. Standard error for a^* values = 0.6; standard error for chroma = 0.8. Least-squares means at each time point with different letters (a to f) are different ($P < 0.05$). Number of replications = 5; 5 replications \times 3 packaging \times 4 storage time points = 60 observations. PVC packaging; HiOx-MAP = 80% O_2 + 20% CO_2 ; CO-MAP = 0.4% CO + 19.6% CO_2 + 80% N_2 . CO = carbon monoxide; HiOx = high-oxygen; MAP = modified atmospheric packaging; PVC = polyvinyl chloride.

Lipid oxidation

The inclusion of CO in MAP of ground chicken lowered ($P < 0.05$) TBARS values (Figure 5) more than HiOx-MAP and PVC-packed samples. Ground chicken patties packaged in HiOx-MAP exhibited the highest TBARS values compared with CO-MAP and PVC. The 80% O_2 used in HiOx-MAP induces significant lipid oxidation compared with PVC. Ground chicken has 72.8% unsaturated fatty acids, and these types of fatty acids are more prone to oxidation than saturated fatty acids. In addition, the release of prooxidants during grinding can further accelerate oxidative changes. More specifically, covalent binding of secondary lipid oxidation products with myoglobin and enzymes promotes myoglobin oxidation (Naveena et al., 2010; Yin et al., 2011; Ramanathan et al., 2014, 2020a, 2020b; Elroy et al., 2015; Nerimetla et al., 2017; Zhai et al., 2019). Excluding or limiting the O_2 content in CO-MAP limited lipid oxidation. Although limited ground chicken studies have reported lower lipid oxidation in CO-MAP, several beef and pork

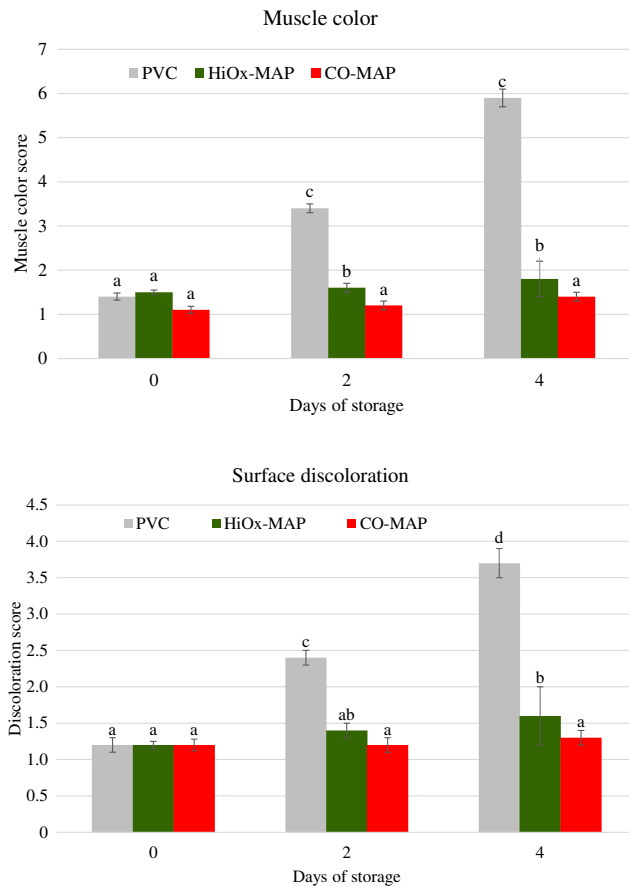


Figure 4. Effects of MAP and storage time on visual ground chicken color. Standard error for muscle color = 0.18; standard error for surface discoloration = 0.15. Least-squares means at each time point with different letters (a to d) are different ($P < 0.05$). Number of replications = 5; 5 replications \times 3 packaging \times 3 storage time points = 45 observations. PVC packaging; HiOx-MAP = 80% O_2 + 20% CO_2 ; CO-MAP = 0.4% CO + 19.6% CO_2 + 80% N_2 . CO = carbon monoxide; HiOx = high-oxygen; MAP = modified atmospheric packaging; PVC = polyvinyl chloride.

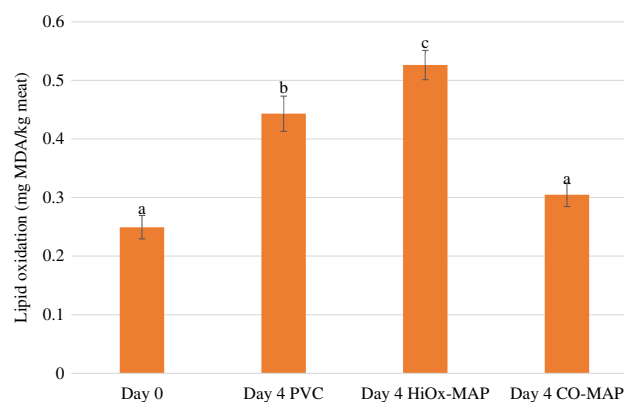


Figure 5. Effects of MAP on ground chicken lipid oxidation (TBARS values). Least-squares means with different letters (a,b,c) are different ($P < 0.05$). Day 0 TBARS values were taken prior to packaging. Standard error bar is included. Number of replications = 5; 5 replications \times 3 packaging \times 1 storage time point = 15 + 5 day 0 = 20 observations. PVC packaging; HiOx-MAP = 80% O_2 + 20% CO_2 ; CO-MAP = 0.4% CO + 19.6% CO_2 + 80% N_2 . CO = carbon monoxide; HiOx = high-oxygen; MAP = modified atmospheric packaging; MDA = malondialdehyde; PVC = polyvinyl chloride; TBARS = thiobarbituric acid reactive substances.

Table 1. Fatty acid profile of ground chicken¹

Fatty Acid	% ²	Standard Error (±)
C8:0	0.05	0.003
C10:0	0.01	0.001
C11:0	0.00	0.000
C12:0	0.02	0.003
C13:0	0.00	0.000
C14:0	0.46	0.004
C14:1	0.13	0.010
C15:0	0.07	0.001
C15:1	0.00	0.000
C16:0	20.04	0.020
C16:1	4.29	0.001
C17:0	0.12	0.020
C17:1	0.06	0.001
C18:0	6.27	0.400
C18:1n9	0.14	0.030
Vaccenic acid	0.00	0.000
C18:1n9c	28.44	2.100
C18:2n6t	0.07	0.001
C18:2n6c	28.41	0.800
C20:0	0.14	0.004
C18:3n6	0.22	0.070
C20:1	0.24	0.050
C18:3n3	1.82	0.100
CLA1	0.04	0.000
C21:0	0.01	0.000
CLA2	0.00	0.000
CLA3	0.02	0.000
CLA4	0.01	0.000
C20:2n6	0.23	0.020
C22:0	0.02	0.010
C20:3n3	0.33	0.020
C22:1n9	0.01	0.000
C20:3n6	0.02	0.000
C20:4n6	1.43	0.400
C22:2n6	0.01	0.000
C24:0	0.00	0.000
C20:5n3	0.08	0.000
C24:1	0.00	0.000
C22:5n3	0.24	0.020
C22:6n3	0.10	0.000
Total ω-3	2.57	0.100
Total ω-6	30.32	0.980
Total ω-9	28.69	0.400

¹Four pooled samples were taken from 5 batches of ground chicken.

²Fatty acid analysis was conducted in triplicates and reported as percentage based on total lipids and corresponding fatty acid methyl ester.

CLA = conjugated linolenic acid.

studies noted lower lipid oxidation in CO-MAP (Mancini et al., 2010; English et al., 2016; Yoder et al., 2021). Poultry meat is more oxidative in nature than beef and pork because of more unsaturated fatty acids

(Rhee et al., 1996). Therefore, in case-ready ground chicken and turkey, natural antioxidants are added to promote shelf life.

Conclusions

In the current research, the use of HiOx-MAP with 80% O₂ was effective in maintaining the red color of ground chicken but promoted lipid oxidation. Both HiOx-MAP and CO-MAP ground chicken patties had greater *a** values (redness) than PVC packaging on day 4 of storage. Visual panelists noted less surface discoloration in CO-MAP than the other 2 packaging types. The storage time increased aerobic plate count, but packaging type had no significant effect on aerobic plate count. Ground chicken in 0.4% CO along with 19.6% O₂ and 80% N₂ maintained a bright light-pink color preferred by consumers without inducing lipid oxidation. The current research suggests that packaging in CO-MAP provides an opportunity for the industry to extend the shelf life of ground chicken.

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