CARBONATED OR GASEOUS ENHANCEMENT SOLUTIONS IMPROVE INJECTED PORK PROPERTIES IN MODIFIED ATMOSPHERE PACKAGING

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Introduction

Injection of enhancement solutions into pork increases pH and palatability ratings and decreases purge and cook loss (Wright et al., 2005). Common enhancement solutions are water and sufficient salt (0.25-0.5 % salt) and phosphate (0.25-0.45 %) to improve tenderness and juiciness without adversely affecting flavor and color or causing over-tenderization (Sheard and Tali, 2004). Modified atmosphere packaging (MAP) with vacuum or gases will alter shelf-life through microorganism inhibition by >15 % carbon dioxide (CO_2) and bloomed color with >20 % oxygen (O_2)(McMillin et al., 1999). Chops were redder with less purge in MAP with 0.4% carbon monoxide (CO) than in high oxygen MAP, with no effect on flavor or acceptability and minimal effects on other characteristics (Wicklund et al., 2006). The present study was conducted to evaluate raw chilled pork enhanced with solutions containing dissolved CO_2 or CO_2 and CO during 4 weeks of 4°C storage in MAP, vacuum, or air-permeable packaging.

Materials and Methods

Eight marketweight pigs fed a commercial 88.58% corn and 10.42% soybean meal diet under approved University Institutional Animal Care and Use Committee procedures were sacrificed at 107 kg average weight. Boneless loins (*M. longissimus dorsi*, 2th thoracic to 2nd caudal vertebrae) were randomly assigned to one of four injection solution treatments after manually removal at 24 h postmortem from left sides of carcasses chilled at 4°C. The day before enhancement injection, the desired gas treatment (20% CO_2:80% N_2, 80% CO_2:20% CO, or 100% CO_2) was injected into the bottom of each of 3 polyethylene barrels containing 4°C water to give 34474 pascals headspace after barrels had been sealed and evacuated to 3-mm Hg vacuum. A 9.09% polyphosphate and 15.15% salt brine solution was made in a 4th barrel. Water or brine pH was measured before storage of all barrels overnight at 4°C. The next day, 11.34 kg of the salt-phosphate brine solution was hand pumped into each barrel to give 2.27% phosphate and 3.79 % salt solutions. Loins were injected at 115% with the desired gaseous enhancement solution. After 5 min. equilibration, weight, color (L*, a*, b*), and pH were measured before slicing loins into 20 1.3-cm chops. Chops were placed on polyfoam trays and randomly assigned to one of 20 packaging-storage treatment combinations (vacuum (VP); 80% N_2:20% CO_2 MAP; 80% O_2:20% CO_2 MAP, air-permeable overwrap (OW) and 0, 1, 2, 3, 4 week storage). Packages were stored in cardboard boxes at 4°C until sampling at the designated storage time. Chops assigned to week 0 were analyzed the day after packaging while samples for other storage times were continuously exposed to cool white fluorescent light (1200 ± 500 lux) for 48 hr before the end of the designated storage time. At each storage time, package gas was measured and chops were analyzed for color, pH, total aerobic counts, and drip loss before cooking to 70°C and cooling for cook loss and shear force measurements. Color calculations were chroma = $\sqrt{((a^*)^2 + (b^*)^2)}$ and hue angle = $\tan^{-1}(b^*/a^*)$. Data was analyzed in a split plot design with loins as main plots, chops within loins as split plots, and a covariate of initial chop pH (SAS, 2003) with two replicate packages at each storage time.

Results and Discussion

Solution pH decreased after gas dissolution because CO_2 solubility is proportional to its partial pressure. Loins injected with 20% CO_2:80% N_2 had the lowest final pH and the lowest pump % (Table 1). Loins injected with 100% CO_2 had the highest pump %. The pH and color before and after injection were not different. Injection treatments did not cause differences in any dependent variables of initial or stored pork chops. Control chops or chops injected with 100% CO_2 enhancement solutions had higher final pH in the different package types (data not shown). The L* values were inconsistent within the different enhancement and packaging treatment combinations (Figure 1), although it was expected that treatments with lower pH or increased drip losses would have lighter color. The a* was higher in chops injected with CO in enhancement solutions with VP and anoxic MAP and lower for control chops in VP, OW, and anoxic MAP. Redness of chops with CO in the enhancement solution decreased during storage in high O_2 MAP and OW. The L* and a* were higher in chops injected with 20% CO_2:80% N_2 after week 1 and lower in control enhanced chops at 3 and 4 weeks.

Table 1. Characteristics of dissolved gas solutions, gaseous enhancement solutions, loins and chops.

Gas Injection Treatment	pH after gas dissolution	Enhance-ment pH	Dissolved CO_2 (g/L)[a]	Loin pump, %	CO_2 in loin, %[a]	Initial loin pH	Final loin pH	Final chop pH
20% CO_2:80% N_2	6.77	7.82	0.775	113.77	0.0065	5.60	5.77	5.68[c]
80% CO_2:20%CO	5.44	6.71	3.089	115.12	0.0282	5.56	5.78	5.67[c]
100% CO_2	5.37	6.94	3.873	116.23	0.0375	5.67	5.86	5.66[c]
No gas	------	7.83	-------	115.33	------	5.65	5.88	5.84[b]

[a]Calculated (Guerra, 2006); [bc]LS means with the same letter are not different (P<0.05).

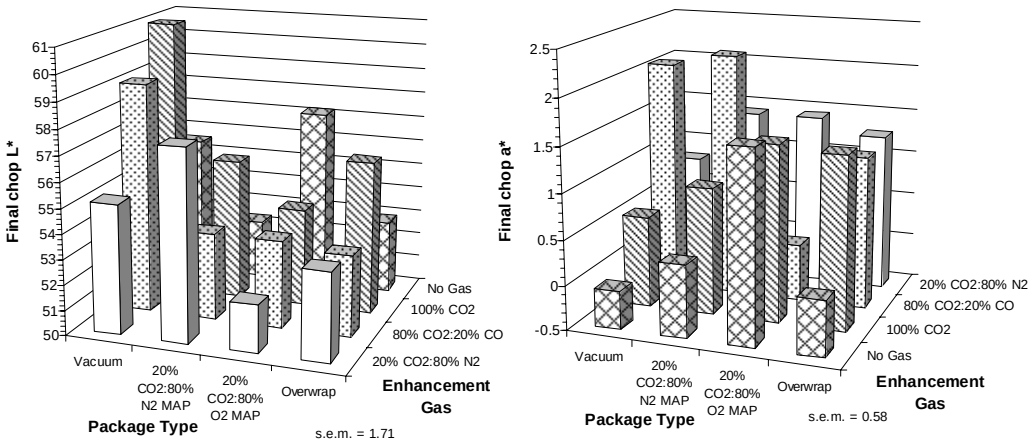

Figure 1. L* and a* of chops with injection and packaging treatment interactions.

The CO_2 in enhancement solutions only minimally lowered pH of enhanced chops during storage, except in treatments injected with 100% CO_2 after 2 weeks. All samples had increased pH at week 4, which was attributed to increased microbial growth by this time. Chop drip losses were relatively constant after the first week of storage, but were higher with VP than MAP or OW. Cooking losses showed a decline with storage time, but the cause for 2 to 6 % higher cooking losses of chops in anoxic MAP than in the other package types could not be explained. Shear force of chops was also slightly variable with different package types over time. It was anticipated that the higher drip losses of chops in VP would result in higher shear force values, but this effect was not observed. Shear force of chops in aerobic packaging was lower than for chops in anoxic packaging after storage weeks 3 and 4. Total aerobic counts were higher in chops with OW packaging at each storage time after initial sampling compared with bacteria counts of chops in other packaging treatments.

Conclusions

Use of enhancement solutions containing CO improved the color in anoxic packaging systems. Enhancement solutions with CO_2 did not affect aerobic microorganism growth while growth was lowered in MAP containing CO_2. All gaseous enhancement solutions and packaging treatments improved shelf life of pork compared with control enhanced pork and pork in air-permeable overwrap packaging.

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