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EFFECTS OF DISTRIBUTION AND DISPLAY GAS MIXTURES ON SHELF-LIFE OF GROUND BEEF IN DYNAMIC GAS EXCHANGE MODIFIED ATMOSPHERE PACKAGING SYSTEMS

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BACKGROUND

Modified atmosphere packaging (MAP) increases the shelf-life of fresh meat (McMillin, 1994); vacuum packaging (VP) and CO_2-enriched packaging have been the most widely used MAP in today's market but meat products have a purple color which is not acceptable to consumers (Allen and Pierson, 1986). A dynamic gas exchange system (Mitchell, 1990; McMillin, 1994) provides extended distribution and a prolonged display shelf-life with a bloomed (oxymyoglobin) color by exchanging an inert distribution gas for high O_2 gas immediately before retail display. Previous reports showed MAP with high CO_2 effectively inhibited microbial growth, but produced brown discoloration and package collapse (Zhao et al., 1993). High O_2 produced a bright-red color on meat surface and accelerated lipid instability in ground beef at 4.4°C (Huang et al., 1993). The objective of the present study was to identify optimal levels of $CO_2/O_2/N_2$ gas mixtures for distribution and display of ground beef in dynamic gas exchange MAP systems.

MATERIALS AND METHODS

Beef steers of choice or high select quality were slaughtered and carcasses were chilled to 4.7°C in the Louisiana State University Agricultural Center Meat Laboratory. At 72 hr postmortem, ground beef from chuck rolls (*infraspinatus* and *supraspinatus*) was formed into, packed into barrier-film lined trays (Amoco Foam, Atlanta, GA) with distribution gas of 20/80, 50/50 or 80/20 CO_2/N_2 (Model 580 tray sealer, Ross Industries, Midland, VA), and stored in cardboard boxes at -1°C. At day 15 postpackaging, gaseous contents were exchanged (Windjammer, Pakor, Inc., Livingston, TX) for display gases of 20/80/0, 20/50/30 or 20/20/60 $CO_2/O_2/N_2$ before display under simulated retail conditions of 4.4°C and 1345 lux cool white fluorescent light. Duplicate packages of each treatment combination were randomly sampled on day 0, 7, 15 (day 0 after gas exchange) and at two-day intervals until day 21.

Objective color data as HunterLab "L", "a", and "b" values were measured (Model LABSCAN-2 0/45, Hunter Associates Laboratory, Reston, VA) immediately after opening packages and were averaged for each patty after rotating 90° among 3 readings. Metmyoglobin formation was estimated using K/S ratio of spectral 572 nm/525 nm and calculations described by Stewart et al. (1965). Headspace O_2 and CO_2 were measured with a Food Package Analyzer (Series 1400, Servomex, Sussex, England). Samples and tray liners were weighed at initial packaging and sampling; weight retention was calculated as sample weight divided by the initial weight. Lipid instability was determined as thiobarbituric acid reactive substances (TBARS, mg malondialdehye/100 g meat sample) (Tarladgis et al., 1960). Psychrotrophic plate counts (PPC) were determined as log colony forming units (CFU) per g by plate count procedures (APHA, 1976) using 10 g sample and suitable serial dilutions incubated at 6°C for 8 to 10 days.

The statistical model was a split-plot design with main plot represented by 3 x 3 factorial of distribution gas mixture and display gas mixture treatment combinations. The sub-plot was storage periods. Data were analyzed by general linear model procedures (SAS, 1985). Least square mean procedures were employed to separate treatment means with differences at $P<0.05$.

RESULTS AND DISCUSSION

After gas exchange, O_2 in packages decreased ($P<0.05$) and CO_2 increased ($P<0.05$) with increased display time (37.8, 34.3, 32.4, and 32.1% O_2 and 26.1, 27.7, 29.3, and 30.0% CO_2 at days 15, 17, 19, and 21). The relative efficiency of gas exchange was ≈70%. Weight loss of ground beef patties increased ($P<0.05$) with storage time (0, 0.26, 0.30, 1.07, 1.64, and 2.45% at 0, 7, 15, 17, 19, and 21 days), but was not influenced by distribution or display gas mixtures. Psychrotrophic microorganism growth and HunterLab "L" values were changed ($P<0.05$) by distribution gases, storage time and the distribution gas-time interaction. Psychrotrophic growth was inhibited ($P<0.05$) by distribution gas mixtures with higher CO_2 (5.61, 5.13, and 4.74 log CFU/g meat for 20/80, 50/50, and 80/20 CO_2/N_2). The relative rate of increased psychrotrophic microorganism growth was influenced ($P<0.05$) by the interaction of distribution gas mixtures and increased storage time.

Patties with 20/80 CO_2/N_2 distribution gas had lower ($P<0.05$) HunterLab "L" (35.9) values than patties with 80/20 CO_2/N_2 (37.4) and 50/50 CO_2/N_2 (36.9). After gas exchange, ground beef patties had higher ($P<0.05$) HunterLab "a" values with 80/20 O_2/N_2 (15.72) compared with 50/20/30 (14.32) and 20/20/60 $O_2/CO_2/N_2$ (13.05) during simulated retail display. Metmyoglobin formation in retail display as measured by K/S ratios were higher for samples in 80/20 O_2/CO_2 (1.84) than samples with 50/20/30 (1.74) and 20/20/60 $O_2/CO_2/N_2$ (1.65). Oxidative instability (TBARS values) was not different ($P>0.05$) among different distribution and display gas treatments, but increased ($P<0.05$) with extended display time (0.20, 1.68, 2.63, 3.94, 5.79, and 7.26 mg malondialdehyde/100 g meat at 0, 7, 15, 17, 19, and 21 days).

CONCLUSION

High levels of CO_2 in distribution gas mixtures inhibited the growth of psychrotrophic microorganisms and patties had increased red color with higher levels of O_2 during display. Oxidative instability of ground beef patties increased with extended display time, but was not accelerated by display gas mixtures with higher O_2. This study indicated that 50/50 CO_2/N_2 distribution gas exchanged for 80/20/0 $O_2/CO_2/N_2$ resulted in more desirable shelf life than other combinations of gas mixtures.

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