CARBON DIOXIDE INJECTION GRINDING AND HIGH OXYGEN MODIFIED ATMOSPHERE PACKAGING EFFECTS ON GROUND TURKEY MEAT QUALITY

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Introduction
Microbial outgrowth and loss of surface redness are major causes of quality changes in meat products, particularly in fresh ground meat. Modified atmosphere packaging (MAP) is widely practiced as an industry method to extend the marketing shelf life of "case ready" meats. In MAP systems involving either O_2 exclusion or high O_2 content, CO_2 is utilized in the atmosphere to slow microbial outgrowth. In high O_2 systems, the typical atmosphere utilized is 60-85% O_2, 15-40% CO_2 and sufficient N_2 to maintain package shape since CO_2 absorbs and dissolves in the meat's aqueous phase (Farber, 1991; Hotchkiss, 1994). The high oxygen level serves to increase the depth of the surface oxymyoglobin layer while the CO_2 concentration slows microbial growth. Colour stability and time to microbial spoilage for meat packaged in high O_2 modified atmospheres are approximately doubled when compared to simple aerobic over-wrapped product (Gill, 1990). Typical grinding involves meat from a mixer being fed into an auger, exiting the cutting assembly, being formed or shaped for packaging and then packaged with the selected modified atmosphere. All steps are conducted in an aerobic environment until the meat encounters the modified atmosphere. The depth of the antimicrobial effect of CO_2 is thus limited by the depth of penetration at the surrounding atmosphere-to-meat surface. This research involves comparison of typical grinding with grinding in a modified CO_2-injection grinder and the effects on surface colour and microbial outgrowth within layers for MAP ground turkey meat.

Materials and Methods
Diced, fresh turkey breast meat was ground by a food processor (Rival Manufacturing, Kansas City, MO) modified with 4 injection holes drilled into the grinding chamber and a copper fitting placed in each hole. A 4.8 mm diameter flexible manifold of 4 flexible tubes from a main CO_2 line was attached to each of the copper fittings of the grinder barrel. The inlet CO_2 pressure was maintained at 35 psi during grinding. The meat was thoroughly mixed and ground with CO_2 by flushing CO_2 at positive pressure into the chamber during grinding. The ground meat was then held in a barrier bag flushed 3 times with CO_2. The bag was heat sealed and stored at 4°C for 1 hr to ensure that there would be no loss of gas until packaging. For non-CO_2 ground samples, the turkey meat was ground as in typical grinding (in air contact) and also held in a heat sealed bag for 1 hr at 4°C. Control (0 day) samples of meat from the bags were analyzed as described below.
Following the brief holding period, meat patties of 220 g each were prepared and then packaged in expanded polystyrene barrier trays sealed with barrier lidstock film (Cryovac – Sealed Air Corporation, Duncan, SC) at an approximate 3:1 headspace-to-meat volume ratio. Trays were packaged using high O_2 (>90% O_2) on a Ross Preformed Tray Packaging Machine (Reiser, Canton, MA) and displayed in light at 4°C ± 2°C until analysis on days 2, 4, and 6. One patty from each treatment was removed from refrigeration and sampled for package gas headspace, meat colour and microbiological counts. For analysis each patty was divided into three layers: top, middle and bottom in contact with the tray.
Headspace analysis was conducted on 3 separate meat samples using a Gow-Mac Series 580 gas chromatograph (Gow-Mac Instrument Company, Bethlehem, PA) equipped with a CTR column operated at 30°C. Surface colour (CIE L*a*b*) of patties was determined using a Minolta Chroma Meter CR-300 (Minolta Corporation, Ramsey, NJ) with an 8-mm diameter orifice and illuminant C. Total aerobic plate counts were determined using pour plates with Plate Count Agar (Difco Laboratories, Detroit, MI) and incubation at 37°C for 48 hr. Aerobic counts were expressed as $\log_{10}$ colony forming units (CFU) per g meat.

Results and Discussion
There was no change ($P \geq 0.05$) in O_2 or CO_2 concentration in the package headspace of ground turkey meat from either treatment during the 6 days of display with the amount of O_2 ranging from 92-96%. The CO_2 ranged from 6% at day 0 to 3-4% at days 2 – 6. The slight shift was likely due to remaining CO2 dissolution into the meat.
Turkey meat ground in the CO_2 environment had lower ($P<0.05$) overall average total aerobic counts within each layer compared to the meat ground in the typical aerobic environment (Table 1). This is likely due to the enhanced effect of CO_2 dissolving in the meat surface during grinding.

Table 1: Grinding treatment average log $_{10}$ CFU/gm of total aerobic bacterial counts in the three layers of the turkey meat patty packaged in high O_2 and refrigerated at 4°C ± 2°C.

Layer of Meat Patty	Ground in CO_2	Ground in Air
Top	4.16 ^{b}	4.84 ^{a}
Middle	4.32 ^{b}	4.98 ^{a}
Bottom	4.30 ^{b}	4.98 ^{a}

Means with the same superscript did not significantly differ (P>0.05), n= 36.

In the first 2 days of storage (day 0 to day 2), there was an increase (P>0.05) in total aerobic bacteria counts for both the meat ground in CO_2 and non-CO_2 ground meat although the increase was less with CO_2 present (Table 2). Also, from day 0 through day 6, bacterial counts increased in all layers (top, middle and bottom) for meat ground in air at a faster rate than meat ground in CO_2. No layer effect was found within each grinding treatment. Although CO_2 was not used at recommended headspace levels (>15%) when packaging the meat, it is apparent that CO_2 injection during grinding has a positive microbial benefit by slowing outgrowth.

Table 2: Days of display and grinding treatment effects on log $_{10}$ CFU/gm of total aerobic bacterial counts in the three layers of the ground turkey meat patties packaged in high O_2 and refrigerated at 4°C ± 2°C.

Days of Package	Ground in CO_2			Ground in Air		
Display	Top	Middle	Bottom	Top	Middle	Bottom
0		3.25 ^{c}			3.36 ^{de}	
2	3.65 ^{d}	3.82 ^{d}	3.75 ^{d}	4.45 ^{c}	4.53 ^{c}	4.61 ^{c}
6	5.34 ^{b}	5.55 ^{b}	5.62 ^{b}	6.44 ^{a}	6.51 ^{a}	6.37 ^{a}

Means with the same superscript did not significantly differ (P>0.05), n= 6.

Surface colour measured as CIE +a* (redness) remained more stable overall in the patties from turkey meat ground in CO_2 compared to patties prepared with meat ground in air (Table 3). The degree of redness for turkey meat patties is much less of that expected for ground beef or poultry thigh meat due to the lower concentration of myoglobin.

Table 3: Surface CIE +a* (redness) for ground turkey meat patties packaged in high O_2 for 6 days under refrigeration (4°C ± 2°C).

Treatment	Days of Storage			
	0	2	4	6
Ground in CO2	5.96a	4.33b	4.33b	2.55c
Ground in Air	4.98b	5.01b	2.94c	1.47d

$^{a-d}$ Means with the same superscript did not significantly differ (P>0.05), n=36.

Oxymyoglobin formed in the high O_2 packaging condition was retained better during the 6 days of display in patties from CO_2 ground breast meat compared to meat ground in air. Maintaining the higher initial CIE +a* value obtained via dissolved CO_2 during grinding and use of the high O_2 concentration in packaging retarded the oxidation of oxymyoglobin to metmyoglobin, the undesirable brown surface pigment. also observed that CO_2 maintained low microbial counts and aided in maintaining ground turkey meat color.

Conclusions

Grinder modification for direct CO_2 injection during turkey meat grinding aided in retarding aerobic bacteria outgrowth in formed meat patties. When combined with packaging in a high O_2 atmosphere, surface redness retention was also improved. This technique of CO_2 enhancement to the meat may also aid in preventing package collapse that occurs with high CO_2 use in MAP for meat products.

References

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