Effect of zilpaterol hydrochloride supplementation of beef steers and calf-fed Holstein steers on the color stability of top sirloin butt steaks

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STORY IN BRIEF

Top sirloin butt steaks were used to determine the effects of supplementing zilpaterol hydrochloride (ZH) to beef and calf fed Holstein steers on color stability. Effects of feeding dietary ZH for 0 d, 20 d, 30 d, or 40 d on feed were compared. Top sirloin butts were divided in half with one half being enhanced and packaged under modified atmosphere packaging (MAP) and the remaining half being packaged under polyvinylchloride film (PVC). Beef steaks packaged with PVC from 30 d (a* = 18.31) cattle had a tendency (*P* = 0.07) to produce a redder steak than the control (a* = 17.00) or 40 d supplemented cattle (a* = 17.05). In beef steaks, ZH had no effect on subjective visual color (*P* = 0.15 to 0.27) and discoloration (*P* = 0.10 to 0.59) of steaks packaged with PVC when stratified by day of display, with the exception of visual color on d 5. Beef steaks under MAP from 20 d cattle were redder (a* = 19.50, *P* < 0.05) than 30 (a* = 18.07) or 40 d (a* = 17.57) cattle, but were similar to the control steaks (a* = 18.68). Overall retail display day and day of supplementation, there was no effect (*P* > 0.05) on objective or subjective color of Holstein steaks under PVC. Dietary supplementation for 20 d produced a higher (*P* < 0.05) b* value on d 1 of display in MAP packaged Holstein steaks. If recommending a period of dietary supplementation, 20 to 30 d would be suggested to result in, on average, the brightest, reddest steaks.

Key Words: beta-agonist, color stability, packaging, top sirloin

INTRODUCTION

Consumers rely on color to measure quality and freshness of meat (Strydom et al., 2007). It has been reported that color is the single greatest factor used by consumers to determine whether or not they will purchase a meat cut (Kropf, 1980). The meat industry has increasingly focused on modified atmosphere packaging (MAP) for fresh, case ready meats to improve color stability (Seyfert et al., 2007). Although MAP packaging does improve shelf life, there is muscle-to-muscle variation in the color characteristics that occur in high oxygen atmospheres (Behrends et al., 2003).

β-agonists are one of the most recent approaches to faster growth production in farm animals (Strydom et al., 2007). Zilpaterol hydrochloride (ZH) is a β-2-agonist which is particularly useful at the level of muscle metabolism (Strydom et al., 2007). While numerous studies have evaluated the impact of β-agonists on carcass quality, limited data exists on the effect of β-agonists on color stability of steaks from beef and calf-fed Holstein steers in simulated retail environments. Therefore, the objective of this experiment was to determine the effect of ZH supplementation on the color stability of top sirloin butt steaks from beef and calf-fed Holstein steers in a retail case setting.

MATERIALS AND METHODS

***Beef Top Sirloin Butts*.** Steers fed at a commercial feedyard were divided into four treatment groups and were fed a dietary supplement of ZH for 0 d, 20 d, 30 d, or 40 d. All ZH was withdrawn from feed 3 d prior to harvest. After harvest, carcasses were chilled until grading when USDA Select carcasses were selected for muscle color evaluation. Sixty-six pairs of top sirloin butts (n = 14 pairs of 0 d ZH, n = 17 pairs of 20 d ZH, n = 18 pairs of 30 d ZH, and n = 17 pairs of 40 d ZH) were identified and tagged prior to fabrication.

Calf-Fed Holstein Top Sirloin Butts. Calf-fed Holstein steers were also fed at a commercial feedlot and divided into the same treatments and withdrawal as above. Sixty pairs of top sirloin butts (n = 15 pairs for each 0 d, 20 d, 30 d, and 40 d supplementation of ZH) were collected.

Postmortem Handling. Upon arrival at OSU, the left top sirloin butt from each pair was randomly assigned for enhancement and modified atmosphere packaging (MAP), while the right top sirloin butt was not enhanced and packaged with a traditional polyvinylchloride film overwrap (PVC). The top sirloin butt assigned to be packaged under MAP was aged in the dark in vacuum packed bags for 7 d at 3°C. The gluteus medius from each top sirloin butt was injected with solution at 4ºC using a 20 (single) needle automatic pickle injector (Fomaco, Model FGM 20/20S, Copenhagen, Denmark) calibrated to inject at 110% of the recorded green weight. Each gluteus medius was enhanced at 110% of the original weight with a solution containing 0.05% NatureGuard rosemary extract, 0.35% Brifisol 85 instant phosphate, 0.3% non-iodized salt, and a mixture of water and ice. Following enhancement and equilibration, three 2.54 cm-thick steaks were cut using a sanitized standard meat slicer. Steaks were then placed into rigid, case-ready plastic MAP trays with absorbent pads. Trays were flushed with 80% oxygen and 20% carbon dioxide, and heat-sealed with a barrier film (LID 1050 film, Cryovac, Sealed Air, Duncan SC) using an in-house G. Mondini MAP machine (Model CV/VG-5, G. Modini S.P.A. Cologne, Italy). The MAP packaged steaks were then placed in boxes in a dark room at 4°C to simulate dark storage and transport for 7 d. Following dark storage, steaks were displayed in a retail-style coffin case under 24 h continuous cool-white fluorescent light (1,600 to 1,900 lux) at 2 to 4°C for 5 d. All packages were rotated daily from side-to-side and front-to-back in the retail-style coffin case to minimize any differences in light intensity or temperature due to location. The top sirloin butts assigned to be packaged with PVC was aged in the dark for 21 d at 3°C. Following removal of the cap, top sirloin butts were sliced and placed on styrofoam trays with absorbent pads and overwrapped with PVC film. After packaging, steaks were immediately displayed in a retail-style coffin case as described above. All packages were rotated daily to minimize any differences in light intensity or temperature due to location.

Retail Shelf Life. Steaks were evaluated using objective and subjective measurement. Visual color of steaks was subjectively evaluated according to the guidelines for meat color evaluation (Hunt et al., 1991). A trained panel (n = 6) evaluated color once a day for 5 d. Initial color was evaluated on d 0 of display in their packaging; panelists were instructed to only characterize the initial appearance of the muscle (1 = purplish pink red or red or reddish tan). Steaks were scored based on lean color (1 = very bright red or pinkish red, 5 = moderately dark red or pinkish red, 8 = tan to brown) and percent surface discoloration (1 = None, 0%; 7 = Total, 100%). The objective evaluation of color for each steak was measured using a Hunterlab MiniScan Spectrophotometer (Model HunterLab, Reston, VA). Each steak was evaluated by obtaining the average score from three sections of each steak, avoiding any seam fat, on d 1, 3, and 5. Each average included a value for L* (lightness; 0 = black and 100 = white), a* (red to green; positive values = red, negative values = green), and b* (yellow to blue; positive values = yellow, negative values = blue).

Statistical Analysis. All results were analyzed using the mixed models procedure of SAS (PROC MIXED, SAS Institute, Cary, NC). The model included treatment (day supplemented with ZH), day of retail display, and the treatment by day interaction as main effects. When a significant F test for one of the main effects or the interaction was observed, mean separation was performed using the least significant difference. All results were evaluated at the nominal significance level of $\alpha = 0.05$.

RESULTS AND DISCUSSION

Beef Top Sirloin Butts. **PVC Packaging**: Least square means for objective and subjective color of PVC packaged steaks over all retail display day for each treatment group is provided in Table 1. The steaks packaged in PVC showed no treatment effect on subjective color or for L* values measured objectively. This is in agreement with previous research by Avendano-Reyes et al. (2006) who documented that meat color was not altered by β-agonist supplementation. However, objective scores for b* were more yellow for 30 d supplementation and there was a trend for a* values to vary by supplementation group. Previous research has also documented a trend to result in paler meat when animals were supplemented with β-2 agonist (Geesink et al., 1993; Vestergaard et al., 1994).

Table 1. Effects of zilpaterol hydrochloride on retail display characteristics of beef gluteus medius steaks displayed under polyvinylchloride film packaging

Item	zilpaterol hydrochloride (day of supplementation) 0	20	30	40	Pr > F	SEM
L*[1]	40.30	41.22	42.18	41.16	0.35	0.75
a*[1]	17.00	17.56	18.31	17.05	0.07	0.38
b*[1]	16.64[b]	17.44[b]	18.40[a]	17.09[b]	< 0.01	0.32
Initial visual color[2]	4.85	4.68	4.31	4.72	0.22	0.19
Visual color[3]	5.03	4.72	4.35	5.11	0.10	0.23
Surface discoloration[4]	2.46	2.34	2.02	2.50	0.36	0.21

[1] L* (lightness; 0 = black and 100 = white), a* (red to green; positive values = red, negative values = green), and b* (yellow to blue; positive values = yellow, negative values = blue).

[2] Initial color (d 0): 1= purplish pink or red or reddish tan of vacuum packages, 9 = very dark red.

[3] Visual color (d 2-5): 1 = very bright red or pinkish red, 8 = tan to brown.

[4] Surface discoloration: 1 = none (0%), 7 = total (100%).

[a,b] Least squares means, in a row, lacking a common superscript letter, differ ($P < 0.05$).

As expected, steaks become darker from day 1 to day 5 of retail display regardless of supplementation group. Over all supplementation groups, the subjective color of the PVC packaged steaks became significantly ($P < 0.05$) darker from d 2 to d 5. The days of supplementation with ZH had no effect on L* or a* when stratified by day of retail display. This finding is not supported by Avendano-Reyes et al. (2006), who found that the meat from all treatment groups supplemented with a β-agonist darkened with time, and the darkening effect was even more evident in the ZH group supplemented during the final 30 d of the experiment. Steaks from cattle supplemented for 30 d had a significantly ($P < 0.05$) higher b* value on d 3 and d 5 of retail display when compared to control and 40 d supplemented cattle. Days of supplementation with ZH had no significant difference among the discoloration scores when stratified by retail display day.

Map Packaging: Overall, 30 d of ZH produced significantly ($P < 0.05$) lighter steaks than those from the control or 20 d of supplementation groups (Table 2). However, while darker, steaks from 20 d of ZH were redder ($P < 0.05$) than 30 d or 40 d of supplementation, they were similar to the control steaks (Table 2). Zilpaterol hydrochloride had no effect on the b* values of the beef top sirloin butt steaks packaged under MAP. On average, initial visual color scores of steaks from 20 d supplemented cattle were characterized as more cherry red ($P < 0.05$) than steaks from 30 d of supplementation. Days of supplementation of ZH had no effect on the overall visual color. Overall, 40 d of supplementation produced steaks with more ($P < 0.05$) overall surface discoloration than steaks from cattle in the 30 d of supplementation group.

Table 2. Effects of zilpaterol hydrochloride on retail display characteristics of enhanced beef gluteus medius steaks displayed under high oxygen modified atmosphere packaging

	zilpaterol hydrochloride (d of supplementation)					
Item	0	20	30	40	Pr > F	SEM
L*[1]	45.72^{bc}	45.18^{c}	47.54^{a}	46.98^{ab}	0.03	0.60
a*[1]	18.68^{ab}	19.50^{a}	18.07^{b}	17.57^{b}	0.02	0.43
b*[1]	18.39	18.41	18.61	18.24	0.48	0.17
Initial visual color[2]	4.48^{ab}	4.77^{a}	3.86^{b}	4.21^{ab}	0.04	0.23
Visual color[3]	3.54	3.57	3.61	3.71	0.84	0.14
Surface discoloration[4]	2.18^{ab}	2.44^{ab}	2.18^{b}	2.84^{a}	0.04	0.18

[1] L* (lightness; 0 = black and 100 = white), a* (red to green; positive values = red, negative values = green), and b* (yellow to blue; positive values = yellow, negative values = blue).
[2] Initial color (d 0): 1= purplish pink or red or reddish tan of vacuum packages, 9 = very dark red.
[3] Visual color (d 2-5): 1 = very bright red or pinkish red, 8 = tan to brown.
[4] Surface discoloration: 1 = none (0%), 7 = total (100%).
[a,b] Least squares means, in a row, lacking a common superscript letter, differ ($P < 0.05$).

Steaks packaged in MAP, as expected, were progressively darker ($P < 0.05$) from d 1 to d 5 of retail display. Overall, the L*, a*, and b* scores decreased from d 1 to d 5. The days of ZH supplementation, when stratified by day of retail display, had no effect on b*, however, did impact L*and a* during display. When stratified by d of retail display, ZH supplementation resulted in no significant difference among the visual color scores for beef top sirloin butt steaks displayed under MAP. According to the trained panelists, on d 2 and 3 of the retail display, steaks from cattle in the 40 d of supplementation group had more discoloration ($P < 0.05$) than the other three supplementation groups.

Calf-Fed Holstein Top Sirloin Butts. **PVC Packaging**: While objective and subjective color declined in acceptability as retail display continued, overall retail display day, day of supplementation did not affect ($P > 0.05$) objective or subjective color stability of Holstein top sirloin butt steaks packaged under PVC film (Table 3). Supplementation with ZH had no effect on the subjective color score or discoloration score on any of the dairy type top sirloin butt steaks packaged with PVC.

Table 3. Effects of zilpaterol hydrochloride on retail display characteristics of calf-fed Holstein gluteus medius steaks displayed under polyvinylchloride film packaging

	zilpaterol hydrochloride (d of supplementation)					
Item	0	20	30	40	Pr > F	SEM
L*[1]	38.58	38.45	38.30	38.58	0.98	0.52
a*[1]	12.48	12.99	12.44	12.63	0.64	0.34
b*[1]	13.48	14.63	13.78	13.93	0.19	0.38
Initial visual color[2]	4.94	4.68	4.62	4.73	0.44	0.14
Visual color[3]	6.15	5.90	6.02	5.96	0.87	0.21
Surface discoloration[4]	4.23	4.09	4.15	4.17	0.94	0.16

[1] L* (lightness; 0 = black and 100 = white), a* (red to green; positive values = red, negative values = green), and b* (yellow to blue; positive values = yellow, negative values = blue).

[2] Initial color (d 0): 1= purplish pink or red or reddish tan of vacuum packages, 9 = very dark red.

[3] Visual color (d 2-5): 1 = very bright red or pinkish red, 8 = tan to brown.

[4] Surface discoloration: 1 = none (0%), 7 = total (100%).

[a,b] Least squares means, in a row, lacking a common superscript letter, differ ($P < 0.05$).

MAP Packaging: Across all retail display day, ZH had no effect ($P < 0.05$) on the L*, a*, or b* scores of the Holstein top sirloin butt steaks packaged under MAP. There was also no overall effect on the initial visual color or the surface discoloration score. However, ZH supplementation did have an effect on subjective visual color across all day of retail display. On average, 20 d of ZH resulted in steaks with higher ($P < 0.05$) visual color score when compared to the control and 30 d of supplementation groups. Stratified by day of retail display, ZH had no significant effect within day on the L*, a*, or b* scores of the Holstein top sirloin butt steaks packaged with MAP (data not presented in tabular form). These results support those of Moloney et al. (1994) who documented that the effects of β-agonists on color are small but commercially important. In addition, days of supplementation with ZH did not significantly affect the amount of discoloration, as scored by panelists.

Conclusion. While this study documents that slight differences do exist in color stability for beef and calf-fed Holstein steaks in each packaging environment, traditional PVC and MAP, the differences are not of a magnitude of concern. If recommending a period of dietary supplementation of zilpaterol hydrochloride, 20 to 30 d would be suggested to result in, on average, the brightest, reddest steaks possible. It would also be more economically beneficial for the feedlot to supplement the diet for 20 or 30 d vs. 40 d. While the product contains a label feeding duration of 20 to 40 d and the manufacturer recommends feeding for 20 d, further research should be conducted to further investigate the differences between 20 and 30 d of dietary supplementation and the impact on color.

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