Individual muscle color stability affects ground beef discoloration when blended with other muscles

C.R. Raines, M.C. Hunt* & J.A. Unruh
224 Weber Hall, Kansas State University, Manhattan, Kansas, 66506 USA.
*E-mail: hhunt@ksu.edu.

Abstract

We evaluated the effects of ground muscles of different color stability on ground beef display color life. Ground muscles were pre-ranked as high (HCS, *M. longissimus thoracis*), intermediate (ICS, *M. semimembranosus*) or low color stability (LCS, *M. triceps brachii*). Six formulations combining HCS, ICS, and LCS muscles were: 50% HCS + 50% ICS; 50% HCS + 50% low; 50% ICS + 50% LCS; 33.3% HCS + 33.3% ICS + 33.3% LCS; 75% HCS + 25% LCS; and 25% HCS + 75% LCS. Formulations were adjusted to 90% and 80% lean using young beef trim. Patties (114 g) for each treatment (n=4 replications) were packaged in HiOx MAP, held in dark storage 5 d, then displayed 4 d. Visual and instrumental color was evaluated. The 80% lean patties containing ≥ 50% HCS had the highest ($P<0.05$) initial visual color. At d 2 and 3, the 75% HCS + 25% LCS at both lean points had the most cherry-red ($P<0.05$) display color. All packages were unacceptably discolored by d 4 of display. Combinations of HCS, ICS and LCS muscle can be mixed without adverse color effects, provided LCS muscle is ≤ 25%, and HCS muscle is ≥ 50% of the blend.

Objective

Our objective was to evaluate interactions of ground muscles of different color stability on the overall color life during display of ground beef.

Materials and methods

Sampling. Cow muscles were pre-ranked as high (HCS), intermediate (ICS) and low (LCS) color stability muscles. Muscles were used: *M. longissimus thoracis* (HCS), *M. semimembranosus* (ICS), and *M. triceps brachii* (LCS). Six ground beef formulations combining muscles of varying color stability were made: 1) 50% HCS + 50% ICS; 2) 50% HCS + 50% LCS; 3) 50% ICS + 50% LCS; 4) 33.3% HCS + 33.3% ICS + 33.3% LCS; 5) 75% HCS + 25% LCS; and 6) 25% HCS + 75% LCS. Each mixture was formulated at both 90% and 80% lean points for a total of 12 treatment combinations. Trim from young beef carcasses was obtained 2 d postmortem and used to achieve the desired lean points. Lean and fat were coarse-ground, then fine-ground, and two patties (each 114 g) from each batch were made by hand using a mold. Patty pH was measured in triplicate by inserting the tip of pH probe (MPI pH probe, glass electrode) into the patty.

Packaging, storage, and display. Patties were packaged in 4.32 cm deep rigid plastic trays and covered with oxygen-barrier film (Lid 550; 1.0 mils; < 20.0 oxygen transmission cc/24 h/m^2 at 4.4 °C and 100% relative humidity (RH); and less than 0.1 moisture vapor transmission g/24 h/645.2 cm^2 at 4.4°C and 100% RH). Patties were packaged in a high-oxygen (80% O_2, 20% CO_2) modified atmosphere (MAP). Because measuring instrumental color in MAP requires opening a package, 2 extra packages of each treatment were made for d 0 and d 2 of display only, and those for use on d 4 were also those evaluated by the visual panel. Packages were stored in dark conditions for 5 d at 2 °C. Packages were displayed for 4 d under continuous fluorescent lighting (2153 lux, 3000K and CRI=85) at 2°C in coffin-type retail display case. To maintain random case placement, packages were rotated daily.

Instrumental and visual color evaluation. Instrumental color (L*, a*, and b*) was measured using a HunterLab MiniScan™ XE Plus Spectrophotometer (Model 45/0 LAV, 2.54-cm-diameter aperture, 10° standard observer) at 0, 0.5, 1, 2, 3, and 4 d of display. Instrumental color was scanned in triplicate and averaged.

Visual panelists (n=6) evaluated patties for 4 d of lighted display. On d 0, initial color was evaluated on an 8-point scale, and panelists were instructed to score patties to the nearest 0.5 visual color unit. The scale used for initial color was: 1 = bleached, pale red, 2 = slightly cherry red, 3 = moderately light cherry red, 4 = cherry red, 5 = slightly dark red, 6 = moderately dark red, 7 = dark red, and 8 = very dark red. Display visual color was scored on an 8-point scale to the nearest 0.5 unit according to the following scale: 1 = very bright red or pinkish red, 2 = bright red or pinkish red, 3 = dull red or pinkish red, 4 = slightly dark red or pinkish red, 5 = reddish tan

or pinkish tan, 6 = moderately dark red or reddish tan or moderately dark pinkish red or pinkish tan, 7 = tannish red or tannish pink, and 8 = tan to brown. Panelist considered a score of 5.5 to be borderline acceptable color.

Statistical analysis. The experiment was a split-plot design with the whole plot being lean combination treatment. Lean point was the subplot. Data were analyzed with MIXED procedure of SAS. The experiment was replicated 4 times. Pairwise comparisons of least squares means were used to determine significant differences ($P < 0.05$).

Results

The trained panel scored the treatments of 50% HCS + 50% ICS, 50% HCS + 50% LCS, and 75% HCS + 25% LCS at the 80/20 lean point to have the most cherry red color (lower initial color scores, P<0.05). The 50% HCS + 50% ICS, 75% HCS + 25% LCS, and 50% HCS + 50% LCS combinations at 90/10 were intermediate in initial color scores. The initial color score of 50% ICS + 50% LCS, and 33% HCS + 33% ICS + 33% l at both lean points did not differ (P>0.05). As expected, the 25% HCS + 75% LCS had the lowest (P<0.05) initial color score within each lean point (Table 1).

Table 1. Initial color score[a] means for ground beef patties sourced from muscles of high (HCS), intermediate (ICS), and low (LCS) color stability formulated to 80% and 90% lean points displayed for 5 d

Muscle combination	*Lean point*	
	80/20	**90/10**
75% HCS + 25% LCS	2.4[b]	2.7[cd]
50% HCS + 50% ICS	2.3[b]	2.6[c]
50% HCS + 50% LCS	2.3[b]	2.9[d]
50% ICS + 50% LCS	3.8[e]	3.9[e]
33% HCS + 33% ICS + 33% LCS	3.0[d]	4.1[e]
25% HCS + 75% LCS	4.9[f]	5.4[g]

[a] 1 = bleached, pale red, 2 = slightly cherry red, 3 = moderately light cherry red, 4 = cherry red, 5 = slightly dark red, 6 = moderately dark red, 7 = dark red, 8 = very dark red

[b-g] Means in any column or row with a common superscript letter do not differ (P>0.05)

The 75% HCS + 25% LCS and 50% HCS + 50% ICS, at both lean points, had the lowest (P<0.05) display color scores, and maintained that advantage through d 3 of display. By d 2, the 25% HCS + 75% LCS at both lean points exceeded the visual color score acceptability threshold (5.5 for the panelists), as was the combination of 50% ICS + 50% LCS at 80/20. By d 4, all samples had visual scores beyond the acceptability threshold, yet the combinations of 75% HCS + 25% LCS and 50% HCS + 50% ICS had the lowest (P<0.05) display color scores (Table 2).

Table 2. Display color score[a] for ground beef patties sourced from muscles of high (HCS), intermediate (ICS), and low (LCS) color stability formulated to 80% and 90% lean points displayed for 5 d

Muscle combination	**d 0**		**d 1**		**d 2**		**d 3**		**d 4**	
	80/20	**90/10**	**80/20**	**90/10**	**80/20**	**90/10**	**80/20**	**90/10**	**80/20**	**90/10**
75% HCS + 25% LCS	1.8[b]	2.1[b]	2.2[b]	2.4[c]	2.8[cd]	3.1[d]	3.2[d]	3.3[d]	6.3[i]	6.7[ij]
50% HCS + 50% ICS	2.0[b]	2.1[b]	2.6[c]	2.7[cd]	3.7[e]	4.4[ef]	3.5[d]	4.6[f]	7.2[j]	7.0[ij]
50% HCS + 50% LCS	2.4[c]	2.5[c]	3.2[d]	3.4[d]	5.4[g]	5.8[h]	3.8[e]	3.9[e]	8.0[k]	8.0[k]
50% ICS + 50% LCS	3.4[d]	3.4[d]	3.8[e]	3.9[e]	5.1[f]	5.9[h]	5.9[h]	6.0[h]	8.0[k]	7.9[k]
33% HCS + 33% ICS + 33% LCS	3.1[d]	3.3[d]	3.3[d]	3.6[de]	4.7[f]	5.0[f]	4.6[f]	5.5[g]	8.0[k]	8.0[k]
25% HCS + 75% LCS	3.8[e]	4.1[e]	4.0[e]	4.2[e]	6.7[i]	6.5[i]	7.6[jk]	7.5[j]	8.0[k]	8.0[k]

[a] 1 = very bright red or pinkish red, 2 = bright red or pinkish red, 3 = dull red or pinkish red, 4 = slightly dark red or pinkish red, 5 = reddish tan or pinkish tan, 6 = moderately dark red or reddish tan or moderately dark pinkish red or pinkish tan, 7 = tannish red or tannish pink, and 8 = tan to brown

[b-k] Means in any column or row with a common superscript letter do not differ (P>0.05)

For L*, combinations containing >50% HCS lean and <50% LCS lean experienced only minor decreases in lightness (L*) during the 4 d display period. Generally, 90/10 combinations were darker in color for each treatment (Table 3). The combination of 75% HCS + 25% LCS and 50% HCS + 50% ICS had the highest a* value by d 4 of display (Table 4). Combinations containing >50% LCS muscles had the lowest a* values by d 4 of display.

Table 3. L* least squares means for ground beef patties sourced from muscles of high (HCS), intermediate (ICS), and low (LCS) color stability formulated to 80% and 90% lean points displayed for 5 d

Muscle combination	d 0		d 2		d4	
	80/20	90/10	80/20	90/10	80/20	90/10
75% HCS + 25% LCS	57.0^{a}	55.2^{b}	54.6^{b}	54.2^{b}	57.2^{a}	52.1^{bc}
50% HCS + 50% ICS	59.4^{a}	57.9^{ab}	57.4^{ab}	55.8^{b}	57.2^{a}	54.6^{b}
50% HCS + 50% LCS	56.3^{ab}	55.5^{b}	56.8^{ab}	54.7^{b}	49.5^{c}	49.1^{c}
50% ICS + 50% LCS	51.5^{bc}	49.6^{c}	55.4^{b}	49.8^{c}	54.4^{b}	51.3^{bc}
33% HCS + 33% ICS + 33% LCS	56.8^{ab}	56.9^{ab}	55.8^{b}	54.2^{b}	52.2^{bc}	50.4^{c}
25% HCS + 75% LCS	49.3^{c}	48.5^{cd}	50.3^{c}	47.7^{d}	47.5^{d}	47.8^{d}

$^{a-d}$ Means in any column or row with a common superscript letter do not differ (P>0.05)

Table 4. a* least squares means for ground beef patties sourced from muscles of high (HCS), intermediate (ICS), and low (LCS) color stability formulated to 80% and 90% lean points displayed for 5 d

Muscle combination	d 0		d 2		d 4	
	80/20	90/10	80/20	90/10	80/20	90/10
75% HCS + 25% LCS	30.5^{a}	27.3^{b}	26.6^{b}	25.2^{b}	23.4^{b}	19.9^{c}
50% HCS + 50% ICS	30.5^{a}	31.0^{a}	17.5^{d}	20.1^{c}	16.5^{d}	14.9^{e}
50% HCS + 50% LCS	30.1^{ab}	30.9^{a}	14.4^{e}	14.6^{e}	10.7^{h}	13.7^{eg}
50% ICS + 50% LCS	31.5^{a}	33.1^{a}	11.7^{g}	13.5^{f}	12.5^{g}	12.1^{g}
33% HCS + 33% ICS + 33% LCS	30.0^{ab}	26.5^{b}	18.1^{d}	20.5^{c}	12.5^{g}	13.5^{eg}
25% HCS + 75% LCS	32.2^{a}	31.8^{a}	19.5^{cd}	18.0^{d}	10.1^{h}	13.0^{eg}

$^{a-h}$ Means in any column or row with a common superscript letter do not differ (P>0.05)

Conclusions and Implications

Low color stability muscles can be incorporated into ground beef at ≤25% while in combination with HCS muscles and retain good display life. Inclusion of low color stability muscles at >25% had negative effects on ground beef display color life. Increased use of ICS muscles also has potential to improve the display color stability of ground beef. Beef color is considered to be an indicator of quality and freshness to consumers (Carpenter, Corforth & Whittier, 2001; O'Sullivan et al., 2002), and is considered to be the first limiting factor in beef shelf-life (Smith, Belk, Sofos, Tatum & Williams, 2000). Segregating and efficiently blending muscles based on color stability properties can improve ground beef color management.

References

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