Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 1 *Cattleman's Day (1993-2014)*

Article 413

2000

Effects of pH, myoglobin form, and endpoint temperature on cooked ground beef color

M.K. Schoenbeck

Donald H. Kropf

Melvin C. Hunt

See next page for additional authors

Effects of pH, myoglobin form, and endpoint temperature on cooked ground beef color

Abstract

Beef quadriceps muscles from nine pH groups (5.5 - 6.4 in .1 increments) were ground; mixed with fat (20%); formed into patties whose myoglobin was in either the oxy or deoxy state; and cooked to four endpoint temperatures (150, 160, 170, or 180°F). Internal cooked patty color was evaluated visually and instrumentally. Patties containing deoxymyoglobin with pH 6.2 or higher and cooked to 150 and 160°F were redder visually and instrumentally than those with a lower pH. Similar trends, but not as pronounced, were observed with patties containing oxymyoglobin. Deoxymyoglobin was more resistant to denaturation and, thus, made patties more susceptible to persistent red color and at a lower pH than those with oxymyoglobin.

Keywords

Cattlemen's Day, 2000; Kansas Agricultural Experiment Station contribution; no. 00-287-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 850; Beef; Ground Beef; Cooked color; pH; Myoglobin form

Authors

M.K. Schoenbeck, Donald H. Kropf, Melvin C. Hunt, S. Hawthorne, and Sally L. Stroda

EFFECTS OF PH, MYOGLOBIN FORM, AND ENDPOINT TEMPERATURE ON COOKED GROUND BEEF COLOR

M. K. Schoenbeck, D. H. Kropf, M. C. Hunt, S. L. Stroda, and S. Hawthorne

Summary

Beef quadriceps muscles from nine pH groups (5.5 - 6.4 in .1 increments) were ground; mixed with fat (20%); formed into patties whose myoglobin was in either the oxy or deoxy state; and cooked to four endpoint temperatures (150, 160, 170, or 180°F). Internal cooked patty color was evaluated visually and instrumentally. Patties containing deoxymyoglobin with pH 6.2 or higher and cooked to 150 and 160°F were redder visually and instrumentally than those with a lower pH. Similar trends, but not as pronounced, were observed with patties containing oxymyoglobin. Deoxymyoglobin was more resistant to denaturation and, thus, made patties more susceptible to persistent red color and at a lower pH than those with oxymyoglobin.

(Key Words: Ground Beef, Cooked Color, pH, Myoglobin Form.)

Introduction

Persistent red color, a phenomenon in which product retains an undercooked, red to pink, internal color even when cooked beyond recommended endpoint temperatures, has become a very costly issue in the ground beef industry. Ground beef patties normally change from red to pink to brown, tan, or grey as endpoint temperatures increase. This color change can be attributed to the denaturation of muscle pigments. Ground beef displaying persistent red color progresses through the normal color changes less rapidly during cooking.

pH critically affects cooked meat color, especially persistent red color. Beef with higher ultimate pH values is more color stable than similar meat with lower pHs. Products with a high pH retain a reddish color despite thorough cooking. Our objective was to determine the effects of a pH continuum, pigment form, and endpoint temperature on cooked color in ground beef.

Experimental Procedures

We used the rectus femoris, vastus lateralis, and the vastus intermedius muscles from 24 peeled knuckles (IMPS 167A) of varying pH's (5.5-6.4). Individual muscles from the quadriceps were sorted into nine pH groups with a muscle pH range of not over 0.1 ± 0.05 pH units per group. Each pH group was coarsely ground separately through a 1/2 in. plate, blended to 20% fat, mixed and ground through a 1/8 in. plate, and formed into patties whose myoglobin was in either the oxy- or deoxy- state. The patties were rapidly crust frozen, individually vacuum packaged, and placed in a –40°F blast freezer. Patties were cooked from the frozen state to one of four endpoint temperatures (150, 160, 170, or 180°F). Internal temperatures of the patties were monitored using a hypodermic probe-type thermocouple inserted in the center. After cooking, patties were sliced in the center parallel to the flat surface and immediately evaluated for cooked color, both visually and instrumentally (a*, redness). The center (35 grams) of each patty was blended with two volumes of cold 40 mM phosphate buffer at pH 6.8 to quantitatively extract myoglobin. Data were analyzed using linear associations by correlation by PROC CORR of the Statistical Analysis System.

Results and Discussion

As expected, visual color scores for patties with higher pH values were redder than those for patties with a lower pH when cooked to the same endpoint temperature. As pH increased, ground beef patties maintained a persistent red color (lower visual scores, higher instrumental a* values) even with higher endpoint temperatures (Table 1). The visual score means of deoxymyoglobin pat-ties were lower (redder) than those for the oxymyoglobin patties. Myoglobin was protected more during cooking in the deoxygenated patties. A visual score of 4.5 and below indicates the presence of pink. Any patty that was cooked to or beyond the recommended cooking temperature (160°F) and continued to display a pink internal color was considered persistently red.

Many patties with pH as low as 5.9 (slightly higher than normal pH) were internally red when cooked to 160°F, the USDA-FSIS (1997) recommended endpoint temperature. The mean visual score for these patties was 4.38 (Table 1).

Our deoxymyoglobin patties at pH 6.1 and higher displayed persistent red color at all endpoint cooking temperatures (Table 1). The visual mean for pH 6.1 patties cooked to 180°F was 4.5. This indicates a slight pink color.

Oxymyoglobin patties cooked to 180°F never showed persistent red color visually, but when cooked to 170 or 160°F were red or pink at pH's 6.2 and 6.4. The patties cooked to the lowest endpoint temperature (150°F) displayed pink or red color at pH 5.9 and higher (Table 1). Premature brown cooked color was noted for oxymyoglobin patties cooked to 150°F from pH 5.6, 5.7, and 5.8 groups.

Both visual and instrumental color evaluation indicate that as pH increases, patties are more likely to retain red color even as temperatures increase. As pH is increased, myoglobin becomes more difficult to denature through cooking. Cooked patties with deoxymyoglobin retain the persistent red color at higher temperatures than cooked patties with oxymyoglobin.

More myoglobin denaturation was seen within the oxymyoglobin patties (Table 2), but myoglobin was protected from denaturation at higher pH levels with either pigment form.

Controlling muscle pH is a difficult task, but high-pH product can be identified prior to grinding. Effective handling practices might minimize persistent red color. Consumers of ground beef must be educated to use an accurate, rapid-response thermometer to determine endpoint temperature. If that temperature reaches 160°F, the ground beef is safe for consumption even if a pink color persists.

Table 1. pH and Maximum Internal Temperature Effects on Visual and Instrumental Redness (a*) of Ground Beef Patties

		Oxymyoglobin - pH								
Item	Temp °F	5.5	5.6	5.7	5.8	5.9	6.1	6.2	6.3	6.4
Visual	150	4.88	5.50	5.63	5.88	4.50	5.38	3.13	5.25	2.75
color	160	5.13	5.88	5.75	5.88	4.75	5.00	3.75	4.63	3.13
score[a]	170	5.88	6.38	6.38	6.50	5.63	5.88	4.50	5.25	4.38
	180	5.75	6.50	6.63	6.38	6.00	6.38	4.88	5.63	5.00
Instrumental	150	7.38	5.98	5.39	5.31	6.36	7.98	11.55	10.44	11.33
color[b]	160	5.56	6.00	5.60	5.31	5.88	8.91	9.19	9.10	11.39
(a*)	170	5.13	5.85	4.95	5.03	5.41	6.28	7.15	7.56	6.92
	180	5.15	5.52	5.26	5.33	5.15	6.40	6.41	7.27	6.53
		Deoxymyoglobin - pH								
	Temp °F	5.5	5.6	5.7	5.8	5.9	6.1	6.2	6.3	6.4
Visual	150	4.50	4.63	4.38	4.63	3.63	3.50	1.25	.63	1.25
color	160	4.63	5.00	5.12	5.00	4.38	4.13	1.38	1.63	.83
score[a]	170	4.88	5.75	5.13	5.00	4.50	4.38	3.00	2.75	3.63
	180	5.38	6.25	5.38	6.25	5.50	4.50	4.38	4.38	4.38
Instrumental	150	8.97	6.94	9.51	7.83	9.28	12.99	16.20	15.85	21.56
color[b]	160	6.29	5.84	8.66	6.40	8.23	10.38	16.31	19.23	16.10
(a*)	170	5.83	5.38	6.29	5.99	6.52	8.12	10.33	19.86	18.44
	180	6.25	5.33	6.57	5.71	5.64	7.09	7.68	18.71	18.02

[a]Color scale: 7-0, .5 increments; 7= grey, 6- brownish grey, 5=tannish brown, 4=tannish pink, 3=pink, 2=slightly reddish color, 1=reddish pink/raw, and 0=raw. Two patties per treatment (pH/temperature). Two visual evaluations per patty. Three instrumental evaluation per patty.
[b]a* is an instrumental value that increases with redness.

Table 2. Myoglobin Denaturation for Oxymyoglobin and Deoxymyoglobin Ground Beef Patties at Each Cooking Temperature Averaged over pH

Myoglobin	150°F		160°F		170°F		180°F	
Denaturation	Oxy	Deoxy	Oxy	Deoxy	Oxy	Deoxy	Oxy	Deoxy
Mean, %	73.5	62.5	78.9	67.0	80.1	75.3	84.8	82.6
Standard deviation, %	20.1	13.2	15.8	11.8	15.5	13.6	13.0	11.8