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FACTORS AFFECTING PREMATURE BROWNING IN COOKED GROUND BEEF

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Summary

Some ground beef patties developed an internal, brown cooked color and looked well-done at temperatures as low as 131°F, whereas normal patties were red to pink. The premature brown color was not related to percent fat; patty compaction; animal source and maturity; pH (5.5 to 5.8); or concentrations of raw patty heme and nonheme iron, myoglobin, and total pigment. Because oxidation-reduction potential and total reducing activities were higher (P<.05) and TBA numbers were lower (P<.05) in normal than prematurely brown patties, the brown color is apparently related to greater patty oxidation.

(Key Words: Ground Beef, Cooked Color, Oxidation, Reducing Activity, Food Safety.)

Introduction

Internal color of cooked meat normally changes from red to pink to tan as endpoint temperatures increase. These colors often are used to assess degree of doneness. However, in some of our earlier studies, a well-done appearance has developed in ground beef at lower than expected temperatures. Because this premature brown color could result in consumers eating undercooked ground beef, concerns for food safety were raised. This research examined the chemical properties of ground beef that turned brown prematurely during cooking.

Experimental Procedures

Samples exhibiting normal and premature brown cooked color were obtained from the quadriceps muscle of A- and E-maturity, British-beef and dairy breeds and from frozen beef trimmings. All raw materials had pHs of 5.5 to 5.8 and fat contents from 3 to 18%. Quarter pound patties were formed, crust frozen (-40°F), vacuum packaged, and stored at -4°F for 2 to 11 months.

Oxidation-reduction potential of raw samples was measured using a platinum redox and a silver/silver chloride reference electrode. TBA values (a measure of oxidation) were determined on raw patties using the perchloric acid extraction method. Total reducing activity, total pigment, and heme and nonheme iron also were determined.

Prior to cooking, external and internal patty colors were assessed visually to the nearest half-point using a 5-point descriptive scale (1=purple red, 2=dark reddish purple, 3=bright red, 4=brownish red, 5=very brown). Patties were cooked to 131, 149, or 167°F on an electric griddle (325°F). Internal temperature was monitored by intermittently inserting a needle thermo-probe into the patty. Patties were cooled for 5 minutes and sliced for internal color evaluation to the nearest half-point using a 5-point descriptive scale (1=very dark red to purple, 2=bright red, 3=very pink, 4=slightly pink, 5=tan, no evidence of pink). A Hunter Labscan

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6000 was used to instrumentally evaluate color. Saturation index (color intensity) was calculated.

Data were analyzed as a completely randomized design where treatments were a 2 × 3 factorial of cooked color group and endpoint temperature. SAS General Linear Models procedures and least square means separation techniques were used.

Results and Discussion

An interaction (P<.05) was found for virtually all cooked color traits. As expected, patties from the normal group exhibited a typical color change during cooking from red to more tan as endpoint temperature increased. At all three end point temperatures, patties that had premature browning were described as slightly pink to tan. Visually, the normal group at 131°F was the most red (P<.05), followed by normal at 149°F (Table 1). Normal patties at 167°F and prematurely brown patties at 131 and 149°F were similar (P>.05) in cooked color. Patties that were prematurely brown were visually similar at 131, 149, or 167°F (P>.05). Instrumental measurements (Table 1) supported visual scores, because normal patties at 131°F were the reddest (highest a*) and most intense in color (saturation index). For most instrumental color traits, the normal patties at 149°F were intermediate in redness (P<.05), whereas normal at 167°F and prematurely brown at 131°F were less red and not different (P>.05). For most instrumental traits, patties that were prematurely brown at 149 and 167°F did not differ (P>.05), and both exhibited the least (P<.05) redness.

Patties that had premature brown cooked color had higher (P<.05) TBA values (Table 2) than patties with normal color. They also had lower (P<.05) total reducing activity and oxidative-reductive potentials. No differences (P>.05) for heme, nonheme, or total pigment occurred in raw patties from the two cooked color groups (Table 2). After cooking, patties with normal color at 131°F retained higher concentrations of extractable pigment and heme iron compared to patties with premature brown color at this temperature. Nonheme iron increased more in patties with premature brown than normal color upon heating to 131°F. Overall, patties with premature brown cooked color were more oxidized and exhibited less reducing ability than patties with normal color.

Table 1. Means for Cooked Internal Appearance Traits of Normal (NRM) and Prematurely Brown (PMB) Ground Beef Patties Cooked to 131, 149, and 167°F

	131°F		149°F		167°F	
Trait	NRM	PMB	NRM	PMB	NRM	PMB
Visual color[1]	2.3^{d}	4.6^{b}	3.6^{c}	4.9^{ab}	4.6^{b}	5.0^{a}
a* Value (redness)	25.3^{a}	15.2^{c}	22.9^{b}	12.8^{d}	16.0^{c}	11.6^{d}
Saturation index	31.4^{a}	22.7^{c}	29.1^{b}	19.8^{d}	22.5^{c}	18.8^{d}

[1]Visual color scores for internal cooked color: 1=very dark red to purple, uncooked appearance; 2=bright red; 3=very pink; 4=slightly pink; 5=tan, no evidence of pink.

[a,b,c,d]Means within a trait without a common superscript letter differ (P<.05).

Table 2. Means for Chemical Traits of Ground Beef Patties with Normal (NRM) and Prematurely Brown (PMB) Cooked Color Raw and Cooked to 131°F

Trait	NRM	PMB
Thiobarbituric acid (TBA) reactive substance (raw), µg/g (fat free)	.50[b]	1.11[a]
Total reducing activity (raw)	5 3[a]	.36[b]
Oxidative-reducing potential (raw), mv	-128[a]	-91[b]
Heme iron, (raw), µg/g patty(fat free)	15.29	14.14
Heme iron (131EF), µg/g patty (fat free)	5.81	4.76
Nonheme iron (raw), µg/g patty (fat free)	6.57	6.33
Nonheme iron (131EF), µg/g patty (fat free)	9.57	10.15
Total pigment (raw), µg/g patty (fat free)	9.92	9.62
Total pigment (131EF), µg/g patty (fat free)	3.73	2.94

[a,b]Means for a trait with different superscript letters differ (P<.05).

Meat Color and Myoglobin

Myoglobin is the pigment that makes meat red. It's similar in structure to hemoglobin found in blood. When a carcass is ribbed, the ribeye surface changes from dark red to bright red because myoglobin at the surface binds oxygen from the atmosphere. Each myoglobin molecule contains an atom of iron. Normally, that iron is in the ferrous (Fe+2) state and is said to be "reduced." However, during retail display, part of the iron converts to the ferric (Fe+3) form and is said to be oxidized. The myoglobin is now brown in color and is called metmyoglobin.

The iron in myoglobin is important nutritionally and is called "heme iron." It's the most biologically available form of iron known.