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Premature browning in cooked ground beef after modifying myoglobin

Abstract
Some ground beef patties developed an internal, brown cooked color and looked well-done at temperatures as low as 131 ÌŠF, whereas normal patties were re d to pink. The premature brown color was not relate d to percent fat; patty compaction; animal source and maturity; pH (5.5 to 5.8); or concentrations of raw patty heme and nonhemeiron, 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.

Keywords
Cattlemen's Day, 1995; Kansas Agricultural Experiment Station contribution; no. 95-357-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 727; Beef; Ground beef; Cooked color; Oxidation; Reduction; Food safety

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PREMATURE BROWNING IN COOKED GROUND BEEF AFTER MODIFYING MYOGLOBIN

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Summary

Some ground beef patties develop an internal, brown cooked color and the patty looks well-done at temperatures as low as 131°F. This study determined if treatment of ground beef to oxidize or reduce meat pigments could influence cooked color. When the myoglobin pigment was chemically oxidized, premature browning occurred, whereas chemically reduced pigment produced normal cooked color. We conclude that biological factors affecting muscle reducing ability must be controlled to retain reducing capacity sufficient to develop normal cooked color of ground beef.

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

Introduction

Internal color of cooked meat typically changes from red to pink to tan as endpoint temperatures increase, and these colors are often used to assess doneness. This assessment is not reliable for ground beef that develops a well-done appearance at final internal temperatures lower than expected. This premature brown color could result in consumption of undercooked ground beef, causing serious concerns for food safety.

In an earlier study we found that heme and nonheme iron, total pigment, percentage fat, patty compaction, animal source or maturity, and pH (5.5 to 5.8) were not different between patties that developed a normal or premature brown cooked color. The present study was done to determine if chemically oxidizing or reducing treatments of normal patties or those that turn brown at low temperatures could influence cooked color when heated to only 131°F.

Experimental Procedures

Patties 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. Patty pH was 5.5 to 5.8, and fat was 3 to 18%. Quarter pound patties were formed, crust frozen (-40°F), vacuum packaged, and stored at -4°F for 2 to 11 month.

Patties exhibiting normal and premature brown cooked color received one of three chemical modifications: 1) no chemical modification (NO); 2) reduced (RD; 10 mL of .05 mM sodium hydrosulfite); or 3) oxidized (OX; 10 mL of .04 mM potassium ferricyanide) for a total of six treatment combinations.

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°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

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(1=very dark red to purple, 2=bright red, 3=very pink, 4=slightly pink, 5 =tan, no evidence of pink). A Hunter Labscan 600 0was used to instrumentally evaluate color. Saturation index was calculated. Expressible juice was squeezed from patties and its color was evaluated to the nearest half-point using a five-point scale (1=dark, dull red; 2=red; 3=pink; 4=pinkish tan; 5=yellow, no pink).

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

Results and Discussion

Because patties from the normal group had higher total reducing activity than those in the prematurely brown group, we examined the effects of modifying the myoglobin state before cooking. Patties with NO and RD modifications did not differ in total reducing activity (P>.05) and both were considerably higher (P<.05) in reducing activity than patties with OX modification (Table 1). The potassium ferricyanide in OX patties may have confounded determination of total reducing activity, because it is the compound monitored for reducing activity. Thus, the extremely low total reducing abilities of OX patties were unexpected.

Raw patty external and internal appearances were altered by chemical modification (Table 1). Visually, patties from normal-RD, prematurely brown-RD, and normal-NO groups were the most (P<.05) purplish red. Patties from normal-OX, prematurely brown-OX, and prematurely brown-NO groups were the most oxidized and brown in appearance. OX modification resulted in patties with a brown external and internal appearance, typical of a metmyoglobin. RD resulted in a purple-red external surface and purple-red internal surface typical of deoxymyoglobin. Instrumental color (not all data shown in Table 1) followed a pattern similar to visual evaluations, with normal patties having higher (P<.05) a* values (more red) than prematurely brown patties. RD patties had the highest (P<.05) a* values and saturation indices, NO was intermediate, and those with OX had instrumental values indicative of being brown.

Patties with normal-RD treatment had the most (P<.05) red internal visual cooked color (Table 1). NO-normal and RD-prematurely brown patties were intermediate and were scored very pink. Prematurely brown-NO and -OX modifications yielded patties that were the least red. Instrumentally (not all data shown), patties from normal-RD and prematurely brown-RD groups had the highest (P<.05) a* values and saturation indices (Table 1).

Although differences occurred in the internal patty appearance between cooked color groups and from the chemical modification, no differences in color of expressible juice were found. The juice from patties from all treatment groups was very red in color. The reason for the disparity in patty color (red vs. brown) and juice color is unknown, but we had found previously that expressible juice color and internal patty color were not highly related. Endpoint temperature was more related to expressible juice color than to internal patty color, especially at low endpoint temperatures.

The relationship between pigment oxidative state and internal cooked color indicates the need for rapid and conscientious handling of raw materials to ensure sufficient reductive capacity in meat that will lead to normal cooked color. Because oxidiation of ground beef leads to the development of prematurely brown internal color, factors influencing metmyoglobin formation also may influence premature browning. Higher storage temperatures promote greater oxygen uptake and more rapid reduction of reducing enzyme activity. Increasing length of time postmor-tem and mechanical manipulation, such as grinding, drastically decrease a muscle's reducing ability. Rapid pH decline during chilling while carcass temperature is still high might promote premature browning by de-creasing myoglobin stability.

Table 1. Characteristics of Ground Beef with Normal and Prematurely Brown Cooked Internal Color at 131 °F

Trait	Meat Color Group	Pigment Chemical Modification		
		None	Reduced	Oxidized
Total reducing activity, raw	Summed over both	.55[a]	.52[a]	-10.0[b]
External visual color, raw [1]	Normal	2.8[b]	2.1[c]	4.5[a]
	Premature brown	4.3[a]	3.0[b]	4.0[a]
External a* values, raw	Summed over both	12.9[b]	24.0[a]	9.9[c]
Internal visual color, raw [1]	Normal	1.9[c]	1.5[c]	4.7[ab]
	Premature brown	4.2[b]	2.0[c]	5.0[a]
Internal a* values, raw [2]	Summed over both	15.1[b]	25.9[a]	10.2[c]
Internal visual color, cooked [3]	Normal	2.4[b]	1.7[c]	4.8[a]
	Premature brown	4.7[a]	2.1[b]	5.0[a]
Internal a* values, cooked	Normal	24.9[b]	30.8[a]	15.7[c]
	Premature brown	15.1[c]	29.7[a]	10.8[d]
Expressible juice visual color [4]	Normal	2.2[a]	2.0[a]	2.2[a]
	Premature brown	2.0[a]	2.0[a]	2.3[a]

[1]Visual color scores for raw external and internal color: 1 =purple red, 2=dark reddish purple, 3=bright red, 4=brownish red, 5=very brown.

[2]An instrumental measure of redness.

[3]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.

[4]Expressible juice color: 1=dark, dull red; 2=red; 3=pink; 4=pinkish tan; 5=yellow, no pink).

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