INFLUENCE OF FORMULATION AND FINAL INTERNAL TEMPERATURE ON COLOR PROPERTIES OF COOKED BEEF PATTIES

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BACKGROUND. Suitable procedures for measuring internal temperature in thin meat products like beef patties are generally not available to consumers. Thus, consumers have been advised to use the absence of pink color as an indication of thorough cooking. However, there is growing evidence to suggest that internal cooked patty color does not accurately relate to internal cooked patty temperatures.

Premature browning (Hague et al., 1994; Hunt et al., 1994; 1995; Lavelle et al., 1995; van Laack et al., 1996a), which is illustrated by patties displaying fully cooked interiors at temperatures below 71°C, clearly implies a potential food safety concern. The opposite situation ("hard-to-cook hamburgers") is exemplified by pink/red color in patties cooked beyond 71°C (Mendenhall, 1989; van Laack et al., 1996ab). This situation can result in tough, dry patties (especially if the product is low-fat) if cooking is terminated when the cooked color finally becomes brown.

OBJECTIVES. The objectives of this study were to determine the influence of variations in raw beef materials (formulations) and final internal temperature on color properties of cooked beef patties.

METHODS. Five separate formulations of ground beef were processed from various raw materials as follows: 10FAT = young cow hindquarter muscle to yield 10% fat; 20FAT = young cow hindquarter muscle with fed cattle boneless plates to yield 20% fat; COW = mature cow hindquarter muscle; HI PH = forequarter muscles obtained 48 h post-mortem from fed cattle with pH > 6.15; HB young cow hindquarter muscle processed immediately following slaughter. COW, HI PH and HB formulations were all processed to have 10% fat. Meat was initially ground through a 1.9 cm plate, mixed and then ground through a 0.3 cm plate before processing into patties (89-90 g). Patties were frozen at -29°C, vacuum packaged and stored at -29 for 2 wk before evaluation.

Patties were cooked from the frozen state on preheated (163°C) electric griddles to either 68.3 or 71.1°C. Internal temperature was measured with iron-constantan, probe-type thermocouples. Cooking times and cooking yields were determined.

Immediately following cooking, patties were divided into two portions (perpendicular to the flat surface of patties) and assessed for degree of doneness using a 12-point scale according to Berry (1994). Fresh cuts on patties were made and instrumental color measurements of CIE L*, a*, b* (Illuminant C), saturation index and hue angle were calculated using a Minolta Chroma Meter (Model CR-200). Moisture and fat analyses were determined on raw patties and pH was assessed on both raw and cooked patties using a probe sensor (Sentron Integrated Sensor Technology). Data were analyzed using ANOVA employing a split-plot design where formulation was the whole plot and final internal temperature the split-plot.

RESULTS AND DISCUSSION. The effects of formulation on color and cooking properties of beef patties were more dramatic than those of final internal temperature (Tables 1, 2). Patties cooked to 68.3°C possessed higher b* values, higher saturation index, lower hue angle and required less cooking time than patties cooked to 71.1°C. L* values were not affected (P > 0.01) by final internal temperature. Similar results for cooked patty color traits in comparisons of 65-66°C vs. 71°C have been reported (Hague et al., 1994; Lavelle et al., 1995). Changes in a* value between 68.3 and 71.1°C temperatures were observed only for HB patties (Table 2). This may be related in some way to the substantial decrease in pH that occurred during cooking for patties from this formulation. Hague et al. (1994), reported that only 34% of the variation in cooked patty color could be attributed to end point temperature (55 to 77°C).

Both formulations (HI PH, HB) designated to have elevated pH possessed mean pH values at least 0.5 units higher than the other formulations (Table 1). These two formulations (especially HI PH) displayed color traits indicative of a more red, uncooked appearance. Several studies (Mendenhall, 1989; Trout, 1989) suggest that when pH > 6.0, undenatured myoglobin is responsible for red color in cooked meat. As mentioned previously, pH of HB patties decreased during cooking (continued post-mortem glycolysis). HB patties exhibited the lowest L* values and received the highest visual degree of doneness (most rare, red) scores, but, had saturation index and b* values similar to formulations (10 FAT, COW) with low pH. It was the only formulation to display a reduction in a* values as a result of increased final internal temperature. Consistent cooked color characteristics may not be one of the many advantages offered by hot processing to ground beef manufacturers.

Patties processed from the "stable" high pH (dark cutting) muscle (HI PH) had the highest saturation index and highest a* values (71.1°C only), but still required the longest cooking times to reach the designated final internal temperatures. Previously, van Laack et al. (1995), found patties processed from dark cutting high pH beef to display more red cooked color and reduced Mb denaturation during cooking than patties made from normal pH beef.

Mature cow (COW) patties showed lower L*, higher a* and lower b* values, lower hue angle values and more red degrees of doneness scores than 10FAT and 20FAT patties. The effects of animal maturity on cooked patty color traits are inconclusive (Marksberry, 1990; Hague et al., 1994). 10FAT and 20FAT patties were given "brown" degree of doneness scores (both final internal temperatures combined). At 68.3°C, the degree of doneness scores were: 10FAT = 5.8, 20FAT = 5.7. Thus, these two formulations may have been conducive to premature browning. It is believed that if metmyoglobin is present in the interior of patties, premature browning can develop (Hunt et al., 1994, 1995; Lavelle et al., 1995). However, in those studies patties were cooked from the thawed state. There is evidence (van Laack et al., 1996a) to suggest, that regardless of the pigment oxidation state, cooking patties in the thawed form produces more premature browning than cooking frozen patties.

CONCLUSIONS. When evaluating broad ranges in ground beef formulations, slight changes in final internal temperature (68.3 to 71.1°C) may not produce easily detectable differences in cooked color characteristics. In terms of preventing premature browning, there appears to be benefits from increasing the pH of beef muscle used in beef patty processing. However, that may result in increased incidence of pink/red cooked color well above 71.1°C internal temperature. Considerable control may be necessary in ground beef processing and cookery if consistent cooked patty color-final internal temperature relationships are to be attained.

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Table 1. Effects of formulation and final internal temperature on pH, color and cooking properties of beef patties

	Formulation[a]					Final internal temperature, °C	
Trait	10FAT	20FAT	COW	HI PH	HB	68.3	71.1
Raw fat content,%	10.0f	19.6c	8.7fg	8.5g	8.9fg	-	-
Raw pH	5.54g	5.67fg	5.71f	6.26e	6.21e	-	-
Cooked pH	5.76f	5.80f	5.81f	6.20e	5.81f	5.87	5.89
L* value	47.8e	48.2e	44.3g	46.0f	41.4h	45.6	45.3
b* value	11.8e	11.8e	10.9f	11.5e	10.4f	11.5e	11.0f
Saturation index[b]	14.0fg	13.7g	15.3fg	18.6e	15.7f	16.3e	15.0f
Hue angle[c]	58.0e	59.3e	46.0f	38.7g	37.5g	47.3f	48.5e
Degree of doneness score[d]	5.8g	5.6g	7.4f	7.8f	9.6e	7.4	7.1
Cooking time, min:sec	5:44f	5:31fg	5:42f	6:40e	5:17g	5:38f	5:52e
Cooking yield,%	74.4g	67.9h	77.2f	73.4g	79.2e	74.9	74.1

[a]Formulation codes - see text. [b]Saturation index = $(a^2+b^2)^{1/2}$ [c]Hue angle = $(\tan^{-1} b/a)$
[d]Based on 12-point scale where higher numbers are more rare and lower numbers are more well-done.
[efgh]Means in the same row within formulation or final internal temperature with different letters are different ($P < 0.01$). Where no letters exist, differences were nonsignificant ($P > 0.01$) in analyses of variance.

Table 2. Interaction effects of formulation and final internal temperature on a* values

	Formulation[a]				
Final internal temperature,°C	10FAT	20FAT	COW	HI PH	HB
68.3	7.7e	7.2e	10.9cd	15.2b	15.2b
71.1	7.2e	6.8e	10.5d	14.1b	12.2c

[a]Formulation codes - see text. [bcde]Any means with different letters are different ($P < 0.01$).