:8 On the possibilities of producing restructured beef steaks possessing attractive red colour during frozen display

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Introduction

In recent years much effort has been put into research and refinement of restructured steaks, ribs, etc. from beef, pork and lamb. Some very successful products have entered the away-from-home market. Products like McDonalds' McRib and the like have proved the acceptance of restructured "intermediate value products" by the general public. No products, however, have so far gained any significant success at the retail level. One reason for that is the poor colour and colour stability. Added salt, the use of freeze/thaw/refreeze cycles and the concentration of oxygen in the products are the main reasons. Neither of these factors can be totally eliminated, but improved colour stability can be achieved by reducing the salt content and the number of freeze/thaw cycles to a minimum, and by allowing for higher (bloomed) or lower (anaerobic) O_2-concentrations. Another possibility for achieving good colour stability is to use meat that still has most of its reducing capacity intact.

Earlier research on the use of hot boned beef in restructured steaks did not focus on colour stability, albeit improved colour appearance has been claimed (1). In this study we have combined objective colour measurements and metmyoglobin determinations to study the colour of steaks made from hot boned chucks from electrically stimulated steer carcasses.

Materials and Methods

Production of restructured steaks. Meat from steers slaughtered at ISU Meat Lab was used. Electrical stimulation (ES) was performed on one side of the split carcasses within 45 min after bleeding (500 V peak, 380-420 mA, 60 Hz sinus, two 15 sec periods). Chuck from the stimulated side was used in the "hot boned" experiments. The ES side chuck was deboned and trimmed to about 10% fat within 2 hours post mortem. Heavy connective tissue was also removed. Flaking was performed immediately following deboning and trimming, when the temperature of the meat was still 26-28°C. The flaked meat was then mixed for 2 minutes with 0.6% salt. After mixing the meat was stuffed into 6 ½" fibrous casings, and kept at 4°C until the pH was 5.7. At that pH value the logs were frozen at -30°C in a blast-freezer.

The non-stimulated side (NS) was chilled at 4°C and aged for 2 or 7 days. The chuck was then deboned and trimmed and restructured products were made as described. Flaking temperature was 7-8°C and the logs were frozen immediately after stuffing.

All logs were kept at -30°C until cut in the deep frozen state or tempered, pressed and sliced at about -5°C, 15-30 days after production. Because of the low temperature, the difference between 15 days for some products and 30 days for others was considered not to have any significant effects on the later experiments.

Cut or sliced steaks, both at a thickness of about 3/4", were wrapped in Goodyear Choice Wrap, Vitafilm. Sliced steaks were kept in the tempering room at approximately -5°C for two additional hours to bloom before refreezing at -30°C. Cut steaks were immediately put back to the deep freezer without any tempering or blooming allowing to take place.

Equipment used in the production of the steaks was: Comitrol Model 1700, equipped with a 3J-30390 head; Leland Food Mixer Mod. 100 DA; Vemag Type 854 vacuum stuffer; Butcher Boy SA-20F bandsaw, Bettcher Press Model 70 and Bettcher Power Cleaver Mod. 39.

Frozen display. Wrapped steaks were kept in 80 ft. cdl light from a Cool White fluorescent lamp at -20°C. Colour and metmyoglobin measurements were performed prior to display, during a 21 days period of display, and immediately after thawing at the end of the display period.

Colour measurements of frozen or thawed steaks. The colour of the products was measured with a Hunterlab Labscan 5100 Spectrocolorimeter.

The standard aperture (44 mm illuminated area) was used. Illuminant F (fluorescent lamp) was chosen for the calculations of the colour values, since fluorescent lamps are widely used in steak display cases in retail stores.

The colour measurements were generally performed on packaged products, with the measurement being taken through the transparent film. This did not substantially influence the readings, since specular reflection is efficiently eliminated by the instrument.

Determination of metmyoglobin. A spectrophotometric method described by K. Krzywicki (2) was used. In this method the absorbance of myoglobin extracts is measured at 730, 572, 565, 545 and 525 nm.

The absorbance at 730 nm is taken as zero, and the relative concentrations of reduced, oxygenized and oxidized myoglobin are calculated using the following equations:

$$\text{I} \quad [\text{Myo}] = \frac{\text{Cmyo}}{\text{C}} = 0.369\ R_1 + 1.140\ R_2 - 0.941\ R_3 + 0.015$$

$$\text{II} \quad [\text{Ox}] = \frac{\text{Cox}}{\text{C}} = 0.882\ R_1 - 1.267\ R_2 + 0.809\ R_3 - 0.361$$

$$\text{III} \quad [\text{Met}] = \frac{\text{Cmet}}{\text{C}} = -2.514\ R_1 + 0.777\ R_2 + 0.800\ R_3 + 1.098$$

where R_1, R_2 and R_3 are absorbance ratios A^{572}/A^{525}, A^{565}/A^{525} and A^{545}/A^{525}, respectively.

C is the total myosin concentration or the sum of Cmyo, Cox and Cmet.

The quality of the measurements can be checked by summing the [Myo], [Ox] and [Met] values to see how close this sum is to 1.00 (obviously the theoretical value). In our experiments the sum was within 1.00 ± 0.02. Only the metmyoglobin level is shown in this paper.

Another test can be made by checking that the value of $(-0.166\ R_1 + 0.086\ R_2 + 0.088\ R_3 + 0.099)^{-1}$ is equal to the millimolar absorbance coefficient (MAC) of myoglobin at 525 nm, i.e. 7.6. (525 nm is an isobestic point for the three myoglobin forms). Krzywicki proposes that the MAC calculated from the above expression should be within 7.6 ± 0.2. In our measurements the MAC value was always between 7.45 and 7.75 and in most cases within 7.6 ± 0.1. To obtain the good results, however, we had to do all absorbance readings at wavelengths that were 1 nm shorter than those proposed by Krzywicki (729, 571 nm, etc.). A Beckman Acta III spectrophotometer was used.

The metmyoglobin of whole steaks was determined on supernatants after centrifugation of 30 g samples immediately after complete thawing, for 30 minutes at 16000 rpm in 50 ml tubes in the Beckman JA20 rotor. The supernatants were diluted 1:10 by phosphate buffer, 0.04M, pH6.8, before the readings.

The metmyoglobin of the surface of the frozen steaks was determined by scraping a thin layer (<1 mm) from about 10 cm^2 areas with a razorblade. About 0.5 g samples were scraped from the surface and put into 5.0 ml buffer in centrifuge tubes. The pigment was extracted by squeezing and moving the meat against the wall of the centrifuge tube with the bottom of a smaller tube. Quantitative extractions were not necessary to obtain reproducable results.

Results and Discussion

Table 1 and 2 show the results of metmyoglobin measurements and colour measurements on products made from hot boned (and electrically stimulated) meat and from chilled (Prod 3) and chilled and aged meat (Prod. 1 and 2) taken from non-stimulated carcass sides. All measurements are made prior to the display period and on non-tempered, non-bloomed products.

The results show that all products made from hot boned meat have very low metmyoglobin levels, while all products made from cold boned meat have appreciable amounts of metmyoglobin.

The colour measurements show that all these non-bloomed products have relatively low a-values, and that the redness of hot boned products are higher than the others.

Table 1. Metmyoglobin levels (per cent of total myoglobin) of non-tempered steaks prior to display.

Prod. no.	Hot boned	Cold boned
1	0.28±0.41	25.75±1.01
2	- 4.80±2.35	32.45±1.34
3	3.28±0.88	13.23±0.70

(Mean values ± S.E. of readings on 4 different steaks)

Table 2. Hunter 'a' values of non-tempered steaks prior to display

Prod. no.	Hot boned	Cold boned
1	10.33±0.31	8.40±0.15
2	10.58±0.15	7.40±0.13
3	11.38±0.46	8.34±0.37

(Mean values ± S.E., n = 4)

According to these results, the minimal requirement to obtain products with acceptable colour, i.e. very low levels of metmyoglobin, is met if hot boned meat is used, hardly so if cold boned (aged 2 days) meat is used, and certainly not if aged (7 days) meat is used as raw materials. In accordance with this, commercially chilled or frozen trimmings or cuts with unknown freshness should not be used in restructured steaks if good colour is of any importance. Such raw materials are likely to induce colour problems.

To obtain acceptable redness, the products must be oxygenized. In order to obtain blooming they must be tempered or thawed in the presence of oxygen. Table 3 and 4 show the metmyoglobin levels and the redness (Hunter 'a'-values) of the products after tempering and blooming. The results are derived from measurements taken on steaks that were tempered as part of the reforming (pressing) and slicing processes. The sliced and wrapped steaks were allowed to bloom for two additional hours in the tempering room (-5°C) before refreezing at -30°C. The tempering process is difficult to standardize, both in commercial practice and in experimental work. Unfortunately, the tempering is a very critical step of the process, since appreciable amounts of metmyoglobin are formed under tempering conditions. The results of the colour measurements (table 4) show that the 'a'-value exceeds 13.0 for most of the products, and that the redness varies a lot from product to product. Some of the variation is probably due to the above-mentioned difficulties in standardizing the tempering conditions. The products made with hot boned meat generally had the highest 'a'-values, all exceeding the arbitrarily set acceptability limit of 13.0. The metmyoglobin contents (table 3) confirm that tempering results in increased myoglobin oxidation. Levels of 10-20% metmyoglobin will influence the colour of the products, making for a less desirable initial colour.

Table 3. Metmyoglobin content of tempered and bloomed steaks prior to display

Prod. no.	Hot boned	Cold boned
1	3.40±1.02	22.48±1.13
2	-0.18±1.64	37.35±1.23
3	15.65±1.03	24.45±0.91

(Mean values ± S.E., n = 4)

Table 4. Hunter 'a' values of tempered (bloomed) steaks prior to display

Prod. no.	Hot boned	Cold boned
1	16.25±0.24	14.70±0.46
2	18.85±0.38	11.88±1.45
3	14.25±0.33	13.55±0.52

(Mean values ± S.E., n = 4)

The results demonstrate that by using carefully controlled tempering, it is possible to obtain bloomed products with very good colour and very low levels of metmyoglobin when hot boned meat is used. This is true even when the products have been stored at -30°C for one month or more, especially if not bloomed until immediately prior to display. Steaks from one production (no. 3) showed relatively high levels of metmyoglobin even in the hot boned products. This could be due to animal differences, but more likely, it is an indication of the criticalness of tempering conditions. These steaks were almost completely thawed during the tempering process, due to relatively high tempering temperature and more thinly sliced steaks (when compared to prods. 1 and 2).

The preceding results show that steaks having very attractive colour (good bloom and essentially no metmyoglobin) can be easily obtained if hot boned meat is used, provided mild tempering conditions are applied. There is no guarantee, however, that the steaks will have acceptable colour after some days in the display case. This was checked by placing the wrapped steaks under light from a Cool White fluorescent lamp at -20°C, and monitoring the discoloration. The results of the 'a'-value measurements are shown in figur 1.

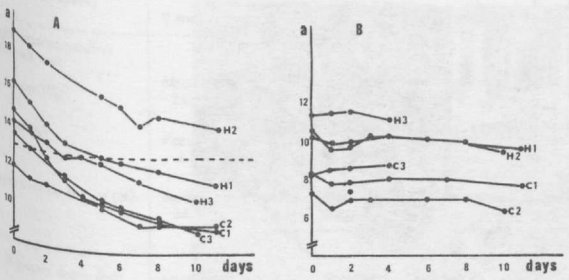

Fig. 1. Redness (Hunter 'a' values) of steaks during frozen display. Tempered (A) and non-tempered (B).
H = hot boned, C = cold boned

The colour stability does not seem to be influenced by the freshness and reducing capacity of the meat (hot boned vs. cold boned and aged), since the 'a'-values of all bloomed products decrease at about the same rate. Due to the good starting colour, however, the hot boned products have a much longer shelflife. Nontempered, nonbloomed steaks did not change the colour to any extent during the display period.

Under no circumstances should a frozen display case be regarded as a storage place for the products. Both lighting and the high, fluctuating temperature accelerate discolouration, fat oxidation, frost formation and freezer burn when compared to the storage freezer. Althought it may not be common practice today in retail stores, there is no reason why products like restructured steaks could not be taken from the freezer to the display case on a daily basis. If this were the case, a colour shelflife of some few days, as obtained with hot boned products, should be acceptable.

Metmyoglobin levels were measured before and after a 21 days period of display, both on the displayed surfaces and on the whole steaks. The results, Fig. 2 and Table 5, confirm the formation of metmyoglobin also in the interior of the steaks, especially the bloomed ones. This applies to both hot and cold boned products, but the metmyoglobin of the hot boned steaks are significantly lower than the others, both in tempered and nontempered steaks.

The results of the surface measurements show a remarkable similarity between tempered and nontempered steaks after the display period. In spite of the constant a-values during the display period (Fig. 1 B) of the nonbloomed steaks, their surface myoglobin oxidized as fast as their bloomed counterparts. This will be further discussed elsewhere.

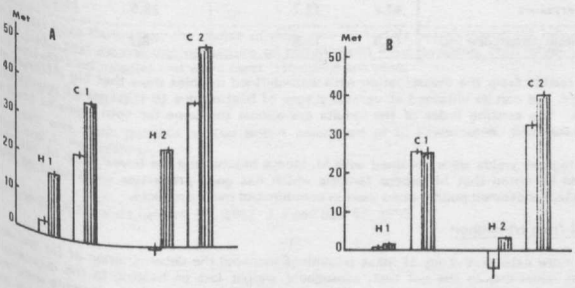

Fig. 2 Metmyoglobin levels (per cent of total myoglobin) of steaks before (□) and after (■) display at -20°C.
Tempered (A) and non-tempered (B).

Table 5 Metmyoglobin levels of displayed surfaces of steaks after 21 days of display

Prod. no.	Hot boned		Cold boned	
	Non-tempered	Tempered (Bloomed)	Non-tempered	Tempered (Bloomed)
1	21.10±0.45	20.50±0.43	39.50±1.16	32.40±3.15
2	20.40±0.20	19.15±0.63	37.73±0.92	45.40±0.63

(Mean values ± S.E., n = 4)

References

1. Breidenstein, B. 1982. Meat Processing International No 2, 16-21

2. Krzywicki, K. 1982. Meat Science 7, 19-36