# 5-P15

## COLOUR OF BEEF *M. LONGISSIMUS DORSI* AND *M. PSOAS MAJOR* HEATED TO DIFFERENT TEMPERATURES

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**Keywords:** meat, beef, colour of meat, thermal treatment, colour stability, oxygenation

### Background

The meat colour is determined by meat pigment myoglobin and its chemistry. It is subjected to a great number of biological (species, sex, age and breed of the animal, type and pH of meat) and technological factors (pre-slaughter treatment, temperature, partial oxygen pressure, eventually packaging and sealing the meat), which in most cases do not affect eating quality of meat after thermal treatment. One of the less studied effects on colour of cooked, heated beef is colour stability of different muscles. Renerre (1984) found that colour stability 168 h *post mortem* was the greatest for the beef *longissimus dorsi* (LD) and the least for the *psoas major* (PM) muscle.

### Objectives

The objective of this experiment was to study the changes in beef LD and PM muscles with respect to its post-mortem colour characteristics and some biochemical factors responsible for the colour variability. The influences of colour stability and oxygenation on colour of beef muscles were assessed after heating to different internal temperatures.

### Methods

The LD and PM muscles (pH < 5.9) of four Simental bulls (18 months) were taken 24 hours *post mortem.* The samples were vacuum packaged, frozen at -35°C and, before analyses, cut into eight samples and thawed: seven were heated to different internal temperatures ($T_i$: 45°C, 50°C, 55°C, 60°C, 65°C, 70°C and 75°C), the eight was raw, unheated. The samples were heated to an adequate internal temperature in the heat controlled water bath. When samples reached the required $T_i$, heating was continued for half an hour. The colour was sensorily and instrumentally (Minolta CR 200b) evaluated on the freshly cut surface of the chilled raw and heated samples, and after a 60 min rest at 0°C in the refrigerator (oxygenated cut). The colour was sensorily evaluated on the basis of printed colour scales showing different hues of three basic colours - black (PB), red (PR) and yellow (PY). Change to one of the three basic colours was noted when this colour was changed by 10 % (Gašperlin *et al.*, 1997a). Depth of oxygenated layer, myoglobin quantification (Trout's $Nit_{409}$ method (1991) modified by Gašperlin et al. (1997b)), specific activity of cytochrome c oxidase (Appelmans et al., 1954) and decrease of $O_2$ concentration (Echo apparatus; Technical report, 1998) were carried out. The data were analysed by the method of least squares using the GLM procedure (SAS, 1989).

### Results and discussions

The data analysis for the colour parameters (Table 1) showed that the interaction between the muscle, heating and oxygenation affected almost all the parameters significantly at the 1% level or less. Panellists did not find colour differences between raw LD and PM (Table 3). Colour of LD and PM muscles were significantly different when they were heated ($T_i$ 45°C to 70°C; PM become brighter and redder) and oxygenated (PM was slightly brighter). Colour of muscles heated to $T_i$=75°C was similar. Heating affects all sensory and instrumental colour parameters (lower PB, PR, PY, 'a', 'b' and higher 'L' value) and DOL, TMP and DOC (lower) too. Oxygenation of the raw and heated slices (except $T_i$ = 75°C ) led to a lower PB and higher PR, 'a' and 'b' values. Correlation analysis showed the 'L' negatively correlated with sensorily evaluated colour parameter PB (R=-0,68). In contrary to our expectations 'a' and 'b' values did not correlate strongly with sensorily evaluated PR and PY (Table 5). There was a negative correlation between PB - 'b' value (R=-0,73). It should be mentioned that members of sensory panel ascribed the presence of yellow (PY) colour in colour hue usually to brightness of the sample (presence of black colour - PB). Based on these facts, panellists had difficulties to evaluate the PY and the inconsequent evaluating can be supposed. No marked differences due to oxygenation were found in the DOL of raw LD and PM (Table 4). Our finding was contrary to Lawrie (1979), who found that after an hour at 0°C the depth of oxymyoglobin was only 1 mm in fillet (where respiratory activity is high - lower colour stability), but 2.5 mm in sirloin (where respiratory level is low - higher colour stability). The heating and interaction between heating and muscle effects on TMP were significant at the 0.1% level (Table2).

Table 1 Effect of Variability and its Significance on Some Sensory Properties and Instrumental Parameters of Beef Colour

| | *Significance of effects (P-value)* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *M* | *H* | *O* | *M×H* | *M×O* | *H×O* | *M×H×O* | *rsd* |
| PB | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0074 | 0.0001 | 0.0001 | 4.06 |
| PR | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 6.34 |
| PY | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.2138 | 0.0854 | 0.0003 | 8.11 |
| 'L' | 0.0001 | 0.0001 | 0.0223 | 0.0001 | 0.0419 | 0.0001 | 0.0489 | 2.31 |
| 'a' | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0221 | 0.0001 | 0.0027 | 1.74 |
| 'b' | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0552 | 0.0001 | 0.0077 | 1.01 |

M: muscle; H: heating to different internal temperatures; O: oxygenation ; rsd: residual standard deviation; PB: presence of black colour; PR: presence of red colour; PY: presence of yellow colour; 'L': lightness; 'a': redness; 'b': yellowness.

Table 2 Effect of Variability and its Significance for Physical and Biochemical Properties of Beef

| | *Significance of effects (P-value)* | | | |
|---|---|---|---|---|
| | *M* | *H* | *M×H* | *rsd* |
| DOL | 0.0004 | 0.0001 | 0.0001 | 0.43 |
| TMP | 0.9686 | 0.0001 | 0.0001 | 1.19 |
| DOC | 0.0720 | 0.0001 | 0.6408 | 1.95 |
| SACCO | 0.2202 | 0.2430 | 0.2112 | 0.87 |

DOL (mm): depth of oxygenated layer;
TMP (mg/g of meat): content of total native muscle pigment
DOC ($m\%O_2/h/g$ of meat): decrease of $O_2$ concentration;
SACCO (mU/mg prot.): specific activity of cytochrome c oxidase.

Table 3 Least Square Means for Sensory Properties and Instrumental Values of Colour and Levels of Significance Between LD an PM Heated to Different $T_i$

| | *Raw* | | | $T_i$ = 45 °C | | | $T_i$ =50 °C | | | $T_i$ = 55 °C | | | $T_i$ = 60 °C | | | $T_i$ = 65 °C | | | $T_i$ = 70 °C | | | $T_i$ = 75 °C | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LD | PM | | LD | PM | | LD | PM | | LD | PM | | LD | PM | | LD | PM | | LD | PM | | LD | PM | |
| Fresh Cut | | | | | | | | | | | | | | | | | | | | | | | | |
| PB | 63 | 62 | NS | 50 | 48 | NS | 40 | 40 | NS | 39 | 34 | ** | 40 | 30 | *** | 30 | 23 | *** | 33 | 26 | ** | 27 | 30 | NS |
| PR | 73 | 73 | NS | 65 | 55 | *** | 44 | 36 | *** | 32 | 36 | NS | 38 | 35 | NS | 35 | 43 | ** | 33 | 38 | ** | 30 | 30 | NS |
| PY | 65 | 72 | NS | 53 | 53 | NS | 50 | 46 | NS | 48 | 46 | NS | 52 | 36 | *** | 48 | 38 | *** | 43 | 38 | NS | 37 | 39 | NS |
| 'L' | 36.5 | 38.5 | * | 43.1 | 44.3 | NS | 44.5 | 49.9 | *** | 49.6 | 53.0 | *** | 49.2 | 55.4 | *** | 52.4 | 55.3 | * | 55.8 | 52.8 | *** | 56.9 | 55.2 | * |
| 'a' | 15.2 | 18.2 | *** | 16.6 | 18.5 | *** | 19.9 | 17.6 | * | 20.0 | 17.6 | *** | 24.4 | 17.6 | *** | 23.5 | 18.4 | *** | 16.6 | 19.6 | *** | 12.9 | 12.4 | NS |
| 'b' | 3.0 | 4.9 | *** | 4.8 | 5.9 | *** | 6.5 | 6.9 | NS | 8.7 | 7.9 | *** | 9.7 | 8.6 | ** | 11.2 | 8.9 | *** | 11.2 | 11.0 | NS | 12.0 | 11.0 | ** |
| Oxygenated Cut | | | | | | | | | | | | | | | | | | | | | | | | |
| PB | 42 | 40 | NS | 33 | 33 | NS | 29 | 20 | *** | 24 | 20 | NS | 20 | 21 | NS | 20 | 26 | NS | 33 | 26 | * | 37 | 40 | NS |
| PR | 74 | 73 | NS | 76 | 66 | NS | 78 | 53 | *** | 53 | 49 | * | 69 | 49 | *** | 52 | 43 | *** | 29 | 43 | *** | 20 | 20 | NS |
| PY | 70 | 64 | NS | 60 | 50 | *** | 63 | 48 | *** | 55 | 47 | ** | 54 | 40 | *** | 50 | 46 | NS | 38 | 47 | NS | 40 | 46 | * |
| 'L' | 38.4 | 39.5 | NS | 43.3 | 45.7 | *** | 46.9 | 50.8 | *** | 51.1 | 54.1 | ** | 53.1 | 55.7 | * | 53.9 | 54.8 | NS | 55.5 | 55.1 | NS | 54.6 | 52.4 | * |
| 'a' | 20.7 | 22.0 | NS | 23.2 | 23.2 | NS | 25.9 | 22.9 | *** | 26.0 | 23.3 | *** | 28.5 | 22.6 | *** | 26.7 | 16.9 | *** | 14.0 | 18.1 | *** | 8.7 | 8.1 | NS |
| 'b' | 11.4 | 12.4 | NS | 13.3 | 13.8 | NS | 15.2 | 14.4 | * | 16.3 | 14.8 | *** | 16.6 | 14.9 | *** | 17.0 | 13.7 | *** | 13.3 | 13.6 | NS | 12.7 | 13.2 | * |

Levels of significance: NS: $P > 0.05$; *** $P \leq 0{,}001$; ** $P \leq 0{,}01$; * $P \leq 0{,}05$; $T_i$ : internal temperature; LD: *m. longissimus dorsi*; PM: *m. psoas major*.

Table 4 Least Square Means in the Sixteen Experimental Groups for Physical and Biochemical Properties of Beef

| | *LD* | | | | | | | | *PM* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Raw* | *45 °C* | *50 °C* | *55 °C* | *60 °C* | *65 °C* | *70 °C* | *75 °C* | *Raw* | *45 °C* | *50 °C* | *55 °C* | *60 °C* | *65 °C* | *70 °C* | *75 °C* |
| DOL | $2.8^{e}$ | $2.8^{e}$ | $2.5^{de}$ | $1.6^{d}$ | $0.2^{a}$ | $0.2^{a}$ | $0.0^{a}$ | $0.0^{a}$ | $2.8^{e}$ | $2.4^{ade}$ | $2.4^{ade}$ | $1.9^{cd}$ | $2.0^{d}$ | $1.0^{bc}$ | $1.0^{b}$ | $0.0^{a}$ |
| TMP | $8.44^{g}$ | $7.94^{fg}$ | $7.89^{fg}$ | $8.07^{fg}$ | $8.06^{fg}$ | $7.36^{fg}$ | $2.79^{b}$ | $0.69^{a}$ | $10.04^{h}$ | $7.85^{fg}$ | $8.02^{fg}$ | $6.94^{def}$ | $6.04^{ce}$ | $6.00^{cd}$ | $5.51^{c}$ | $0.90^{a}$ |
| DOC | $6.34^{ab}$ | $3.71^{ac}$ | - | - | $3.50^{ac}$ | - | - | $10.85^{d}$ | $7.11^{ab}$ | $6.09^{a}$ | - | - | $4.48^{a}$ | - | - | - |
| SACCO | $1.92^{bd}$ | $1.48^{abcd}$ | - | - | $1.15^{abc}$ | - | - | $0.74^{abc}$ | $0.84^{abc}$ | $1.30^{ab}$ | - | - | $1.07^{ab}$ | - | - | $0.93^{a}$ |

$^{a,b,c,d,e,f,g,h}$ Means with the same letter were not significantly different (P> 0.05)

Oxygen in meat is used (when the autooxydation of lipids and microbiological contamination is ignored) by the oxygenation of the meat pigment or/and by the mitochondrial respiration (Lanari in Cassens,1991). On the basis of further investigations with the Oxymax apparatus (Columbus) (Gašperlin *et al.*, 1995), more extensive DOC results on the PM samples were provided (due to extensive respiration) than on the LD. But results on the Echo apparatus showed (Table 2) that the differences in DOC between muscles were coincidental. Respiratory activity of muscles was also determined by measuring of specific activity of cytochrome c oxidase, but it was not affected (Table 2) by the studied factors.

Table 5 Correlations Between Colour Parameters

| | Correlation Coefficient | | |
|---|---|---|---|
| | PB | PR | PY |
| 'L' | -0.68*** | -0.68*** | -0.67*** |
| 'a' | -0.33*** | 0.55*** | 0.30*** |
| 'b' | -0.73*** | 0.01 | -0.11* |

## Conclusions

- sensorily evaluated colour of raw LD and PM was similar; instrument noticed differences;
- colour of LD and PM muscles was significantly different when they were heated ($T_i$ 45°C to 70°C) and oxygenated;
- colour of LD and PM muscles heated to $T_i$=75°C was not affected by the studied factors;
- an increase in $T_i$ was accompanied by changes of all sensory and instrumental colour parameters, as well as a lowering of DOC, DOL and TMP;
- oxygenation of the raw and heated slices (except $T_i$ = 75°C ) led to a lower PB and higher PR, 'a' and 'b' values;
- PB was negatively correlated with 'L' and 'b' values.

## Literature


Appelmans, F., Wattiaux, R., Duve, C. de. (1955) Tissue Fractionation Studies. 5. The association of acid phosphatase with a special class of cytoplasmic granules in rat liver. *Biochemical Journal* 59, 438-445.

Gašperlin, L., Žlender, B., Marn, I. (1995) Influence of myoglobin content and oxygen consumption on oxygenation of fresh and roasted normal and DFD young beef. In: 9th World Congress of Food Science and Technology, July 30 - August 4, 1995, Budapest, Hungary : abstracts. Budapest: The Hungarian Scientific Society for Food Industry: The International Union of Food Science and Technology, 1995, vol. 2, p.153, P442.

Gašperlin, L., Žlender, B., Pegan, A.(1997a) Illustrated colour standards for fresh and cooked young beef. In: Technology - Food - Health. 1st Slovenian Congress on Food and Nutrition with International Participation, Bled, Slovenia, April 21-25 1996. Proceedings. Ljubljana, Association of Food and Nutrition Specialists of Slovenia, 464-467.

Gašperlin, L., Abram, V., Žlender, B., Špendja, R. (1997b) The content of native and denatured myoglobin in thermal treated beef : comparison of two analytical methods. In: Technology - Food - Health. 1st Slovenian Congress on Food and Nutrition with International Participation, Bled, Slovenia, April 21-25 1996. Proceedings. Ljubljana, Association of Food and Nutrition Specialists of Slovenia, L 18-07, 870-876.

Lanari, M.C., Cassens, R.G. (1991) Mitochondrial activity and beef muscle color stability. *Journal of Food Science* 56(6), 1476-17479.

Lawrie, R.A. 1979. Meat Science, 3 rd edition. Pergamon press, Oxford.

Renerre, M. (1984) Variabilite entre muscles et entre animaux de la stabilite de la couleur des viandes bovines. *Sciences des Aliments* 4(4), 567-584.

SAS (1989) *SAS/STAT User's Guide*, SAS Inst., Ins., Cary, NC.

Technical report (1998) ECHO apparatus. Holobar, A. ed., ECHO d.o.o. Slovenske Konjice, Slovenia, 5p.

Trout, R.G. (1991) A rapid method for measuring pigment concentration in porcine and other low pigmented muscles. In: 37th International congress of meat science and technology, September 1-6, 1991 Kulmbach. Proceedings, Vol. 2. Kulmbach, ICOMST, 75-80.