Post mortem variation in pH, temperature and colour profiles of electrically stimulated veal carcasses in relation to preslaughter blood haemoglobin content [1].

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Background and objectives

In the Netherlands, carcass colour is visually assessed during the early post mortem period according to classification standards with a scale from 1 (light) to 10 (dark) by an experienced grader using a colour scale (Hulsegge et al., 1996). For an objective instrumental colour determination the use of a Minolta Chroma Meter for measurement of surface muscle colour of the rectus abdominis muscle has been shown to be highly related with the visual evaluation at 45 min post mortem (Eikelenboom et al.,1992).

The colour of meat depends on the concentration of heme pigments and the muscle structure influenced by the rate and extent of pH fall. Blood haemoglobin concentration has been shown to be correlated to veal colour classification (Miltenburg et al., 1992; Wilson et al., 1995). The influence of the rate and extent of pH fall on colour has been extensively studied (McKeith et al., 1982; Eikelenboom and Smulders, 1986; Buts et al., 1986; Smulders et al., 1989; Guignot et al., 1994; O'Connor et al., 1994). However, the combined effects of blood haemoglobin concentration, live animal characteristics, carcass handling and characteristics on colour were not systematically evaluated in the previously mentioned studies.

The objectives of this study were to investigate the post mortem variation in pH, temperature and colour profiles of electrically stimulated veal carcasses and to determine the relationships between colour and blood haemoglobin concentration, carcass handling and characteristics.

Methods

Animals. A total of 1207 Holstein-Friesian bull calves (age: between 26 and 29 weeks) were slaughtered at 6 slaughter days in two commercial slaughter plants in The Netherlands. The animals were slaughtered in batches of approximately 200 at each experimental slaughter day. Plant 1 and plant 2 were visited 3 times. About two weeks before slaughter, heparinized blood samples were taken from the jugular vein for determination of the haemoglobin (Hb) concentration. After heparinization and lysing of the red blood cells, Hb concentration in mmol/l was determined according to a method described by the International committee for Standardization in Haematology (1978).

Slaughter procedure and measurements. After a transportation time varying between 0.5 and 2 hours, calves were held in lairage for 0.5 to 1 hour before being slaughtered. Calves were stunned with a captive bolt and shackled by the hindleg. Electrical stimulation was applied (plant 1: 40 V, 14 Hz in combination with 3000 V, 1 Hz; plant 2: 80 V, 14 Hz in combination with 4000 V, 1 Hz) after bleeding. In plant 1, carcasses passed through 3 chilling rooms at temperatures of - 5°C (30 min), - 4°C (30 min) and - 3°C (60 min). In plant 2, routine carcass handling included passing carcasses through chilling rooms at - 10°C (18 min) - 9°C (60 min) - 8°C (60 min) and - 3°C (60 min) before being stored at 1,5°C overnight. Carcasses were weighed and judged visually for conformation, fat cover and color score at approximatively 45 min p.m. Conformation was evaluated using the EUROP classification (Walstra, 1991) with five main classes, further divided into three subclasses (E^+ = 1, E^o = 2, E^- = 3, to P^- = 15). Carcass fat cover score was assigned with five classes (range of 1 = lean to 5 = fat). Carcass color was assessed visually according to current classification standards in The Netherlands with a scale from 1 (light) to 10 (dark) by an experienced grader using a color scale (Hulsegge et al., 1996). At 45 min, 3, 24, and 48 h p.m., surface muscle color was measured with a Minolta Chromo Meter on the rectus abdominis (RA) muscle after taking aside the covering fascia. The colour was described as coordinates, e.g. L* and a* representing lightness and redness, respectively. Muscle pH and temperature were measured in the longissimus lumborum muscle (LL) at the height of 8 to 10th lumbar vertebra. Data were analyzed with an analysis of variance model (GLM procedure, SPSS 7.5). Fixed effects in the model were main effects: EUROP-conformation class (15 classes), fat cover score (5 classes) and colour class (10 classes). Slaughter days were introduced as random factor. Differences between factors or combinations of factors were compared pairwise with Fisher's t-test. Pearson correlation coefficients were calculated.

Principal results and discussion

In Table 1 the results of the total population are presented per conformation score as visually evaluated according to the EUROP classification system. Carcass weight was significantly different between EUROP classes and a significant correlation between EUROP classification score and carcass weight has been found (r= -0.55). Higher conformation scores were associated with higher muscle temperatures. Lower ultimate pH values were observed for carcasses with higher conformation scores. No significant differences in blood haemoglobin concentration and instrumental colour parameters were found between conformation scores.

In Table 2 the results are presented per colour classification score. Blood haemoglobin concentrations and colour scores were positively correlated (r= 0.54; $P<0.05$). L* allowed for the best discrimination of the colour classes as 6 significantly different groups were obtained among the 7 classes represented in this experiment. At 45 min, 3 and 24 hours p.m., the correlation coefficients between colour classification scores and L* values were -0.60, -0.61 and -0.56, respectively. These results are in agreement with previous studies (Eikelenboom et al., 1992 ; Klont et al., 1996).

Between colour classification scores only small differences in pH and temperature at 48 hours p.m. were observed. From a study (Guignot et al., 1994), it has been concluded that high ultimate pH decreased both lightness and redness of longissimus muscle.

As variations in ultimate pH were induced by adrenalin adminstration before slaughter, ultimate pH reached values of 6.25 versus 5.59 in untreated animals. In this experiment, lower ultimate pH values (pH 5.55) were obtained and the observed variation was not sufficient to test such a relationship. It should be noted however that pH and temperature measurements were performed on the longissismus lumborum muscle whereas colour was carried out on the rectus abdominis muscle.

In general, meat is becoming lighter during storage as compared to the measurements performed soon after slaughter (Table 2). This should not be a problem for the retailers and the consumers who prefer a pale muscle colour in veal. However, it has been observed in a previous study (Klont et al., 1996) and in this experiment that some groups of carcasses are becoming darker as compared to the colour classification at 45 min p.m. In 2 groups of carcasses the percentage of carcasses becoming darker reached 15% at 24 hours p.m. and 4% at 48 hours p.m. This effect could not be explained by variations in blood haemoglobin concentrations and ultimate pH. Further investigations are needed to establish which factors are responsible for the occurrence of darker carcasses during storage as compared to early p.m. evaluation of colour. This concern will be the object of a more comprehensive study in cooperation with the Dutch veal meat industry.

Conclusions

- Carcasses with different conformation scores did not exhibit differences in blood haemoglobin concentration and instrumental measurements of colour.
- Colour classification scores were highly correlated to blood haemoglobin concentrations measured before slaughter and colour (L* values) of the RA muscle at 45 min, 3 and 24 hours p.m. This implicates that an objective instrumental veal colour classification can be developed.

References

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Table 1. Mean values per EUROP-conformation score. n_m maximal number of observations per conformation score.

	Uo	U-	R+	Ro	R-	O+	Oo	O-	P+	Po	P-
	n_m=3	n_m=3	n_m=24	n_m=40	n_m=93	n_m=312	n_m=475	n_m=167	n_m=59	n_m=19	n_m=11
Carcass weight (kg)	188.2^{h}	167.2^{g}	168.8^{g}	168.5^{g}	165.8^{g}	161.3^{f}	157.0^{e}	146.8^{d}	134.3^{c}	120.0^{b}	97.5^{a}
Haemoglobin (mmol/l)	5.4	5.3	5.4	5.5	5.6	5.5	5.6	5.4	5.4	5.6	5.6
pH 45 min	6.51	6.15	6.31	6.37	6.41	6.46	6.47	6.52	6.49	6.36	6.51
3 h	6.25	6.26	6.10	6.14	6.13	6.13	6.16	6.17	6.20	6.10	6.21
24 h	$5.53^{a,b}$	$5.52^{a,b}$	5.50^{a}	5.51^{a}	5.56^{b}	5.60^{c}	5.63^{d}	5.67^{e}	5.67^{e}	$5.63^{c,d,e}$	5.70^{e}
48 h	$5.45^{a,b}$	$5.47^{a,b}$	$5.45^{a,b}$	5.44^{a}	5.48^{b}	5.51^{c}	5.51^{c}	5.54^{d}	5.55^{d}	$5.56^{d,e}$	5.61^{e}
T 45 min	40.2	39.0	38.8	38.7	38.9	38.8	38.6	38.5	38.5	38.4	38.2
(°C) 3 h	29.3^{f}	27.4^{f}	26.9^{f}	27.2^{f}	26.6^{f}	25.2^{e}	24.4^{d}	22.8^{c}	20.9^{b}	20.2^{b}	17.2^{a}
24 h	4.3^{e}	4.4^{e}	4.3^{e}	3.9^{e}	3.5^{d}	2.4^{c}	2.1^{b}	1.7^{a}	1.5^{a}	1.3^{a}	1.2^{a}
48 h	1.8^{c}	2.3^{c}	2.0^{c}	2.1^{c}	2.0^{c}	1.7^{b}	1.7^{b}	1.7^{b}	1.6^{b}	0.8^{a}	0.8^{a}

^{a,b,c,d,e,f,g,h} Mean values within a row with different superscripts differ significantly ($P<0.05$).

Table 2. Mean values per colour classification score.

	3	4	5	6	7	8	9
	n_m=8	n_m=90	n_m=365	n_m=420	n_m=258	n_m=45	n_m=19
Carcass weight (kg)	153.0	148.4	154.3	156.5	158.3	161.8	161.4
Haemoglobin (mmol/l)	4.8^{a}	4.8^{a}	5.1^{b}	5.5^{c}	6.2^{d}	6.8^{e}	7.0^{e}
pH 45 min	6.48	6.51	6.45	6.46	6.46	6.50	6.49
3 h	6.17	6.12	6.13	6.15	6.20	6.15	6.21
24 h	5.60	5.64	5.63	5.60	5.62	5.64	5.60
48 h	5.53^{b}	5.53^{b}	5.52^{b}	$5.51^{a,b}$	5.50^{a}	5.52^{b}	5.52^{b}
T 45 min	38.1^{a}	38.4^{a}	38.6^{b}	38.6^{b}	38.8^{c}	38.9^{c}	38.9^{c}
(°C) 3 h	23.0	22.3	23.8	24.6	25.7	24.8	23.7
24 h	1.9	1.8	2.2	2.5	2.6	1.9	2.0
48 h	1.5^{a}	1.5^{a}	1.6^{a}	1.8^{b}	1.8^{b}	1.9^{b}	2.2^{c}
L* 45 min	50.3^{f}	49.8^{f}	48.0^{e}	46.9^{d}	44.9^{c}	43.4^{b}	42.0^{a}
3 h	49.3^{f}	48.5^{f}	46.5^{e}	45.3^{d}	44.0^{c}	42.7^{b}	40.8^{a}
24 h	53.1^{f}	52.2^{f}	50.6^{e}	49.4^{d}	47.5^{c}	46.5^{b}	44.9^{a}
48 h	53.3^{*}	51.5^{*}	50.9^{*}	49.9^{*}	48.6^{*}	48.1^{*}	48.7^{*}
a* 45 min	14.2^{a}	14.9^{a}	15.6^{b}	15.9^{c}	16.0^{c}	16.3^{d}	16.5^{d}
3 h	14.6^{a}	15.4^{a}	16.7^{c}	17.6^{d}	16.9^{c}	16.0^{b}	$16.5^{b,c}$
24 h	15.3^{a}	16.3^{a}	17.0^{b}	17.8^{c}	18.4^{d}	18.5^{d}	18.9^{d}
48 h	15.6	17.9	17.6	18.1	18.5	19.4	18.0

* Significant interaction between colour classification score and extent of carcass motion after shackling ($P<0.05$), results not shown.