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Effect of genotype and sex on meat colour changes in rabbit

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Abstract

A study based on 150 carcasses of rabbit crosses of three breeds: Flemish Giant (FG), New Zealand White (NZW) and Californian (CAL) was conducted to determine the changes that occur within the first 24 h *post mortem* in the meat color parameters, i.e. lightness (L*), redness (a*), yellowness (b*), chroma (C*) and hue (H*), in the rabbits of different genetic groups and sexes. Four groups were formed: FN (FG bucks×NZW does); FC (FG bucks×CAL does); FN×C (FN bucks×CAL does); FN×FN (FN bucks×FN does). Meat colour was measured on the surface of *Longissimus dorsi* (LD) and *biceps femoris* (BF), 45 min and 24 h *post mortem*. The genetic groups differed significantly in the meat colour parameters of the LD and BF muscles at both times after slaughter. After 24 h, a* and b* values of the LD muscle were highest in FC group (18.05 and 6.65, respectively) and the lowest in FN×FN group (16.46 and 4.75, respectively). The greatest color difference (ΔE) of the LD muscle was in FN×FN rabbits (9.85) and the smallest in FC group (5.07). The differences between genetic group in color parameters of the BF muscle were smaller but significant, which indicates that crossbreeding may be used in practice to change meat color. Sex did not influence significantly the color parameters of the muscles at either time, although the a* and C* values of the BF muscle were higher in males than females.

Keywords: rabbits, meat quality, meat colour

Introduction

Meat colour is the first trait that consumers perceive when assessing the external appearance of fresh meat products. Being related to meat freshness, it may have a significant impact on the decision of whether or not to buy a certain food product (Boles & Pegg 2001). Colour, one of the most important characteristics of the technological and culinary quality of meat, is influenced by such factors as animal breed, sex, age, type of muscle, and system of feeding, pre-slaughter handling and slaughtering but mostly depends on the amount of myoglobin present in the muscle tissue.

Among all of the animal species used for meat production, rabbit is often included in the group with highest values of meat lightness and a relatively low saturation colour. According to colour, rabbit meat is classified as white meat along with poultry meat it resembles most although its colour is brighter and deeper. As follows from literature (Gondret *et al.* 2005b, Hernández *et al.* 2006, Metzger *et al.* 2006) the color of rabbit meat is mostly not evaluated until after 24 h *post mortem*, which explains the lack of supporting knowledge on the changes that occur during the earlier hours.

Crossbreeding is one of the fast tools offered to the breeders to improve many traits in farm animals (Nofal *et al.* 1997).

The objective of this study was to evaluate the instrumental meat colour changes of *longissimus dorsi* and *biceps femoris* muscles in rabbit of different genetic groups and sexes within the first 24 h *post mortem*.

Material and methods

For this experiment, rabbit carcasses were derived from the crossing of four genetic groups (n=150). Two groups consisted of two-breed crosses from the mating of Flemish Giant (FG) bucks with New Zealand White (NZW) does – group FN (n=40) and FG bucks with Californian (CAL) does – group FC (n=38). The third group (FN×C, n=32) consisted of a three-breed cross from the mating of crossbred bucks (FN) with CAL does. The fourth group (FN×FN, n=40) was the F_2 generation from the FN cross mating. Rabbits were housed in the same environment in closed rabbitry in wire cages (2 rabbits/cage). The rabbits were fed (*ad libitum*) pellets containing 16.5 % protein, 14 % crude fibre, and 10.2 MJ metabolizable energy. The animals were slaughtered at the age of 12 weeks, in compliance with the Polish national regulations for commercial slaughtering. The slaughterhouse was close to the farm, so stress due to transport was minimal. Hot carcasses were suspended in a ventilated area for 45 min, and then were chilled at 4 °C until 24 h *post mortem*.

Meat color was measured on the surface of *Longissimus dorsi* (LD) and *Biceps femoris* (BF), 45 min and 24 h after slaughter, at room temperature (20 °C) with a CR-400 Minolta Chromometer (Minolta Co., Ltd., Osaka, Japan) according to the CIELab standards (CIE 1976) using light source D65 and 8 mm Ø measuring area. Based on the data obtained for colour components, i.e. lightness (L*), redness (a*), and yellowness (b*), the values of colour saturation (chroma; C*), color hue (hue; H*) and colour difference (ΔE) were calculated from the following formulae (CIE 1976):

$$H^* = tan^{-1}(b^*/a^*),\ C^* = (a^{*2} + b^{*2})^{0.5},\ \Delta E = ((\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2)^{0.5} \quad (1)$$

The results were analysed by the least squares method using the General Linear Model (GLM) procedure (SAS/STAT v8.2 (SAS Institute Inc., Cary, NC, USA). The linear model included genetic group, sex and interaction genetic group × sex as fixed effects. Data were presented as the least squares means and the pooled standard error of the mean, with the significance levels of the effect.

The differences between the least squares means for experimental groups were examined using the Tukey-Kramer multiple comparison test.

Results and discussion

The meat colour changes on the surface of LD and BF muscles of rabbits from different genetic groups and sexes are given in Tables 1 and 2, respectively.

Interaction between the factors was nonsignificant in all cases, so the results were omitted.

The genetic groups differed significantly in the values of L*, a*, b*, C* and H* parameters recorded on the surface of the LD muscles (Table 1). After 45 min, the meat of the LD muscle

of FN × C and FN × FN rabbits had significantly higher lightness (L*), and lower redness (a*), yellowness (b*) as well as chroma (C*) and hue (H*) than the meat of FN and FC genotypes. After 24 h, the lightness of the same muscle was significantly higher in the FN × FN group, than in the FC group. The redness and chroma were lower in the FN × FN and FN × FC groups than in FC, while the yellowness and hue were lower in the FN × FN and FN × FC groups than in the FC and FN groups. The greatest colour difference (ΔE) expressing the colour change with time was observed in the FN × FN rabbits. High values of ΔE indicate that the dynamics of changes in the rabbit meat color during 24 h ageing can be perceived by the consumer. Similar results regarding meat lightness 24 h after slaughter, but lower for redness and yellowness were obtained by Metzger *et al.* (2004) in crosses of meat breed. Even lower values of the color components were also recorded by Cavani *et al.* (2000). The high values of chroma obtained in our investigations should be regarded as an advantage, because such meat has a characteristic distinct colour. Comparison of the meat color parameters of rabbit considered in the present paper with those of rabbit purebred meat breeds and their crosses studied by Łapa *et al.* (2008) shows that the presence of Flemish Giant in the genotypes of crosses results in carcasses with darker meat.

Table 1
Colour parameters of *longissimus dorsi muscle* at 45 min and 24 h after slaughter in rabbits of different groups and sexes

	Genetic group				Sex		SEM	*P*-value	
Trait	FN	FC	FN´C	FN´FN	Male	Female		Group	Sex
n	40	38	32	40	75	75			
L^{*45}	55.79^{a}	55.42^{a}	57.85^{b}	59.41^{b}	56.95	57.29	0.39	0.0001	ns
a^{*45}	15.51^{a}	16.74^{a}	11.18^{b}	10.64^{b}	13.59	13.44	0.36	0.0001	ns
b^{*45}	2.31^{a}	1.26^{a}	−0.60^{b}	−1.52^{b}	0.06	0.66	0.28	0.0001	ns
C^{*45}	15.62^{a}	16.94^{a}	11.38^{b}	10.94^{b}	13.64	13.80	0.36	0.0001	ns
H^{*45}	0.07^{a}	0.14^{a}	−0.07^{b}	−0.16^{b}	−0.027	0.016	0.02	0.0001	ns
L^{*24}	55.45^{ab}	54.71^{a}	55.09^{ab}	55.97^{b}	55.22	55.39	0.29	0.0163	ns
a^{*24}	17.42^{ab}	18.05^{a}	15.98^{b}	16.46^{b}	16.99	16.96	0.37	0.0021	ns
b^{*24}	6.30^{a}	6.65^{a}	4.91^{b}	4.75^{b}	5.70	5.60	0.27	0.0001	ns
C^{*24}	18.55^{ab}	19.25^{a}	16.79^{b}	17.23^{b}	17.99	17.92	0.40	0.0001	ns
H^{*24}	0.35^{a}	0.35^{a}	0.29^{b}	0.27^{b}	0.32	0.31	0.01	0.0001	ns
ΔE	6.04^{a}	5.07^{a}	8.22^{b}	9.85^{c}	7.61	6.98	0.35	0.0001	ns

ns: not significant, FN: cross of Flemish Giant × New Zealand White, FC: cross of Flemish Giant × Californian, FN × C: three-breed cross from the mating of crossbred bucks (FN) with Californian does, FN × FN: F_2 generation from the FN cross mating

Genotype affected also the meat color parameters of the BF muscle (Table 2). After 45 min, the meat lightness (L*) of the FC rabbits was higher than that of the other genetic groups. The redness (a*) and chroma (C*) in the FC group were lower compared to the FN × C and FN × FN groups. The FN × C and FN × FN rabbits exhibited higher yellowness (b*) and hue (H*) than the FN animals.

After 24 h, the L* value of the same muscle, was significantly higher in the FC than FN group, while the values of a* and C* were higher in the FN × FN rabbits compared to the FN and FC groups. The FN × FN rabbits had also a higher value of b* than the FN animals. The genetic groups did not differ in the value of H*. The meat color difference (ΔE) was smallest for the FN×C groups. Other authors (Chiericato *et al.* 1996, Pla *et al.* 1996, Dalle Zotte & Ouhayoun

1998) studying *biceps femoris* reported diverse findings. In two studies lower values of L* were measured in rabbits of large body size, in one study the value of a* was higher in the line of large body size, and in two studies the value of b* was higher in the line of smaller body size, selected for litter size. For the lightness (L*) of the hind leg muscles, Bovera *et al.* (2004) achieved the results similar to the ones presented in this paper, while for the red component, Bovera *et al.* (2004) recorded a lower negative value, and Dal Bosco *et al.* (1997), a higher value. Very high chroma and very low hue values such as those obtained in our study reflect a high redness (a*). Compared to the L* and b* parameters the red component (a*) of the meat colour is very sensitive to early *post mortem* changes in muscle temperature (Lindahl *et al.* 2006) and depends mainly on the ratio between the contents of myoglobin, oxymyoglobin and metmyoglobin (Dal Bosco *et al.* 1997).

Table 2
Color parameters of Biceps femoris muscle at 45 min and 24 h after slaughter in rabbits of different groups and sexes

	Genetic group				Sex		SEM	*P*-value	
Trait	FN	FC	FN´C	FN´FN	Male	Female		Group	Sex
n	40	38	32	40	75	75			
L^{*45}	54.67^{b}	56.51^{a}	54.87^{b}	54.79^{b}	54.97	55.46	0.32	0.0002	ns
a^{*45}	12.56^{ab}	11.89^{a}	13.29^{bc}	13.52^{c}	13.10^{a}	12.53^{b}	0.22	0.0001	0.025
b^{*45}	1.13^{b}	1.42^{ab}	2.03^{a}	1.93^{a}	1.48	1.78	0.18	0.0036	ns
C^{*45}	12.67^{ab}	12.04^{a}	13.48^{bc}	13.67^{c}	13.24^{a}	12.69^{b}	0.23	0.0001	0.032
H^{*45}	0.09^{b}	0.12^{ab}	0.15^{a}	0.14^{a}	0.11	0.14	0.01	0.0315	ns
L^{*24}	55.86^{b}	56.95^{a}	56.17^{ab}	56.41^{ab}	56.07	56.63	0.25	0.0358	ns
a^{*24}	13.80^{a}	13.91^{a}	14.05^{ab}	14.79^{b}	14.50^{a}	13.77^{b}	0.22	0.0065	0.004
b^{*24}	4.57^{a}	4.78^{ab}	4.64^{ab}	5.26^{b}	4.84	4.78	0.13	0.0030	ns
C^{*24}	14.56^{a}	14.73^{a}	14.80^{ab}	15.71^{b}	15.30^{a}	14.60^{b}	0.24	0.0025	0.009
H^{*24}	0.32	0.33	0.32	0.34	0.33	0.32	0.008	ns	ns
ΔE	4.51^{a}	4.38^{a}	3.48^{b}	4.60^{b}	4.30	4.19	0.20	0.0079	ns

ns: not significant, FN: cross of Flemish Giant × New Zealand White, FC: cross of Flemish Giant × Californian, FN × C: three-breed cross from the mating of crossbred bucks (FN) with Californian does, FN × FN: F_2 generation from the FN cross mating

In other animal species meat colour is also influenced by the crossbreeding. Latorre *et al.* (2003) studied the effect of sire breed on meat colour in pigs reported that Pietrain × Large White crossbred had a higher yellow score and more intensive color of meat, than Danish Duroc and Dutch Duroc × Large White. Brewer *et al.* 2004) evaluated several sire lines reported that genetic line affected loin lightness, pinkness and a* parameter. Genotype of chickens also plays a major role in meat quality. The slightly darker meat of Black-boned chicken and the higher redness of Northern Thai native chicken muscle have been reported by Jaturasitha *et al.* (2008).

The meat color parameters measured on the surface of the LD muscles 45 min and 24 h after slaughter were not affected by the sex (Table 1), which indicates that the LD muscles of males and females were similar in colour. By contrast, sex had some effect on the colour of the BF muscles (Table 2). Within 45 min and 24 h after slaughter, males showed higher values of a* and C* (meat redder and more coloured) than females. No other sex-related differences were found in the L*, b*, H* and ΔE value of the BF muscle. Cavani *et al.* (2000) also recorded lower

a* and C* values in the muscles of female rabbits compared to males, and a lack of significant differences between sexes in the values of other colour parameters.

The factors that may affect meat colour after slaughter, its pH, water holding capacity and other quality traits are histological and biochemical properties of meat such as muscle fibre type, number, proportions, oxidative and glycolytic properties, and glycogen and lipid content. The structure and function of animal muscle fiber types are revealed in metabolic differences in the red and white fibers. Red fibers are narrow in diameter, myoglobin rich, and adapted to aerobic (oxidative) metabolism for rapid, fatigue-resistant activity, whereas white fibers are larger in diameter, adapted to anaerobic (glycolytic) metabolism and fast-fatiguing (Lefaucheur 2006, Gondret *et al.* 2005a).

The changes in the rabbit meat colour during the first 24 h after slaughter depend mainly on the changes in the red and yellow components with an insignificant impact of lightness. This indicates that the change in the colour of rabbit meat is due to the chemical change in muscle proteins with a minor contribution of the structural changes in muscle fibers, and its ability to absorb and reflect light rays.

In general, genotype affected the meat colour parameters of the LD and BF muscles both 45 min and 24 h after slaughter, suggesting that crossbreeding may be used in practice as a means for changing meat colour. Sex did not influence the colour parameters of the muscles at either time point, although the redness and chroma of the BF muscle were higher in males than females.

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