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Original article

Preliminary observations on the colour variability of breast meat ('magrets') in force-fed ducks

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Abstract — Fifty-eight force-fed mule ducks were used to evaluate the variability of 'magret' (breast meat) colour. Trichromatic coordinates in the CIELAB system (L*, a*, b*) were measured at 4 and 24 h post mortem and after 6 days of storage at +4 °C under an oxygen-permeable film. At 24 h post mortem, the colour of breast meat was visually assessed and the 'magrets' were assigned to one of three colour groups (normal, intermediate, pale). At 24 h post mortem, 22% of the magrets were classified as very pale, and showed higher L* and b* than those classified as normal. These differences were maintained over the 5 days storage but their magnitude was not increased. The L* and b* values were significantly and positively correlated with the content of intramuscular fat ($r = 0.50$, $P < 0.01$ and $r = 0.29$, $P < 0.05$, respectively). The different measurements could not clearly demonstrate that the abnormal colour was due to myoglobin and lipid oxidation and/or colour defects such as those encountered in PSE (Pale, Soft, Exudative) meat. These preliminary observations showed a high variability of breast meat colour in force-fed ducks. Further research is needed to elucidate the underlying mechanisms.

duck / overfeeding / meat quality / colour

Résumé — Observations préliminaires sur la variabilité de la couleur des magrets de canards. Cinquante huit canards mulards gavés ont été utilisés pour étudier la variabilité de la couleur des magrets. Les coordonnées trichromatiques (L*, a*, b*) ont été mesurées en fin de ressuage, à 24 h et 6 jours post mortem, après une conservation à +4 °C sous film perméable à l'oxygène. Une appréciation subjective de la couleur était réalisée à 24 h post mortem et les magrets étaient affectés à une des trois classes de couleur (normale, intermédiaire, pâle). À ce stade, la couleur présentait une variabilité importante : 22 % des magrets examinés avaient une couleur pâle, associée à une luminance (L*) et un indice de jaune (b*) plus élevés que les magrets de couleur 'normale'. Ces différences étaient

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maintenues pendant 5 j de conservation à + 4 °C, mais ne s'accentuaient pas. Les coordonnées L* et b* étaient positivement et significativement corrélées à la concentration de lipides intramusculaires ($r = 0,50$, $P < 0,01$ et $r = 0,29$, $P < 0,05$, respectivement). Sur la base des mesures réalisées, la variabilité de la couleur des magrets ne pouvait pas être attribuée de manière certaine à l'oxydation de la myoglobine et/ou des lipides ni à l'expression de défauts de qualité tels que ceux des viandes PSE (pâles, molles et exsudatives). Cette étude souligne l'intérêt d'étudier plus en détail le déterminisme des défauts de couleur des magrets de canard.

canard / gavage / qualité de la viande / couleur

1. INTRODUCTION

Colour is one of the most important quality traits of meat. It strongly contributes to its overall aspect and therefore to the acceptability by consumers and to subsequent purchase behaviour. In overfed ducks, little attention has been paid to the determinism and stability of meat colour, as compared to other meat or poultry species. As evidenced by the measurements of trichromatic coordinates, overfeeding increases the paleness and yellowness of breast muscles in ducks [12, 14], as well as in geese [2]. In addition, overfeeding increases the level of intramuscular fat [11, 14]. According to Salichon et al. [12], the physical and biochemical properties of duck meat are very close to those of red beef meat but with an increased level of intramuscular fat after overfeeding. These characteristics would make meat from overfed ducks particularly susceptible to oxidation. Theses authors also demonstrated that antioxidant supplementation during overfeeding, i.e. vitamin E, reduces lipid oxidation in breast muscles as well as reducing the lightness and yellowness of the meat, although the effect of overfeeding could not be fully eradicated by vitamin E supplementation. In beef, it is well known that lipid and myoglobin oxidation, and therefore meat colour, are closely related [4, 6], but to our knowledge, this relationship has never been demonstrated in duck meat.

This work was a preliminary step towards the study of meat colour in overfed waterfowls. The main objectives were (i) to evaluate the variability of breast meat colour and its stability during storage and (ii), to identify future research needs for the control of meat colour in overfed waterfowls.

2. MATERIALS AND METHODS

2.1. Bird management

Three hundred male mule ducks were raised in 3 parks of 100 birds each. From the age of 5 weeks, the birds had free access to an outdoor area. The food composition and the feeding regimen have been described previously by Auvergne et al. [1]. The birds were transferred to individual crates where they were overfed by the distribution of 25 meals (2 meals per day) composed of soaked corn. Overall, only 60 birds were randomly chosen and overfed in two series of 30 birds each, starting at the ages of 82 and 97 days, respectively. Thus, the two slaughter series correspond to different ages of the ducks.

2.2. Slaughter and post mortem measurements

The birds were slaughtered under commercial facilities. The ducks were killed by cutting the neck blood vessels after electrical water bath stunning. At 20 min post mortem, a 2 g sample of the right pectoralis major muscle was taken and homogenised in 18 mL of 5 mM sodium iodoacetate. The

pH of the homogenate was measured using a combined glass electrode and referred to as pH_{20}. At 4 h post mortem, corresponding to the end of the carcass chilling process under commercial facilities, the right pectoralis major muscle, i.e. the 'magret', was cut off, without the skin, and the colour was measured on a fresh cut as trichromatic coordinates (L*, a*, b*) using a Minolta chromameter CR 300. The a*/b* ratio was calculated since it is generally considered as an indicator of myoglobin oxidation (e.g. [9]): the ratio decreases when oxidation increases.

The breast muscles were then placed in a polystyrene tray, wrapped in an oxygen permeable film, and transferred into a refrigerated vehicle to the laboratory. At 24 h post mortem, the pH and the colour were measured as described above. A 10 g sample was taken for the determination of intramuscular fat (IMF) content [5]. The 'magrets' were weighed and stored for 5 further days at +4 °C. At 6 days post mortem, the colour was measured and the 'magrets' were weighed. The drip loss was calculated as the difference in weight between days 6 and 1 post mortem, expressed as the % of weight at day 1.

2.3. Visual classification of the 'magrets' according to colour

At 24 h post mortem, the variability of 'magret' colour was visually appreciated and, accordingly, the muscles were assigned to one of the three following colour groups:

– normal, for the muscles showing a red colour on the cut and on the surface,

– intermediate, for the muscles showing a slightly paler colour with a pinky trend,

– pale, for the muscles showing a very pale colour with a yellow appearance.

2.4. Biochemical analyses

At 24 h post mortem, a subgroup of 10 magrets was chosen using the following criteria: 5 muscles randomly taken among the 'normal' group and the 5 palest muscles of the 'pale' group. These muscles were immediately transferred to the INRA Meat Research Centre where they were submitted to the following measurements:

– the trichromatic coordinates at days 2 (reception day), 3 and 6 post mortem;

– the percentage of metmyoglobin at days 2, 3 and 6, according to Krzywicki [7];

– the TBA-RS (Thio Barbituric Acid Reactive Substance) index of lipid oxidation at days 2 and 6 [8]. The results were expressed as mg di-aldehyde malonic per kg muscle.

2.5. Statistical analysis

Analyses of variance were performed using the GLM (General Linear Model) procedure of SAS [13]. The model included the main effect of slaughter series (including the 'age' effect), colour group, and the first order interaction. When variance analysis revealed a significant effect, the differences between the groups were tested using the 'LSD' multiple range test. Subjective score data were treated by non parametric analysis of variance, using the 'NPAR1WAY' procedure of SAS [13]. The means were compared using the Wilcoxon non parametric test for paired-mean comparison when appropriate.

3. RESULTS

The intermediate and pale groups were associated with a significantly lower pH value at 20 min post mortem than the normal one, whereas the ultimate pH did not vary significantly between the colour groups (Tab. I). It is worth noting that there was no significant interaction between the slaughter

Table I. Average breast meat characteristics of force-fed ducks according to subjective colour classification and age (slaughter series) (m ± SEM).

	Colour class			P^1	
	Normal (n = 35)	Intermediate (n = 10)	Pale (n = 13)	Slaughter series	Colour class
pH 20 min	5.95 ± 0.02 [a]	5.73 ± 0.04 [b]	5.86 ± 0.04 [c]	NS	**
pH 24 h	5.65 ± 0.01	5.63 ± 0.01	5.63 ± 0.01	NS	NS
Weight (g)	259 ± 4.5 [a]	264 ± 6.2 [ab]	281 ± 5.8 [b]	NS	*
Drip loss (%)	1.3 ± 0.05 [a]	1.0 ± 0.07 [b]	1.2 ± 0.08 [ab]	NS	*
IMF (%)	3.93 ± 0.13 [a]	5.11 ± 0.32 [b]	4.60 ± 0.19 [b]	NS	**
4 h post mortem					
L*	38.9 ± 0.4 [a]	41.9 ± 0.4 [ab]	42.3 ± 0.5 [b]	NS	***
a*	21.7 ± 0.4 [a]	25.1 ± 0.3 [b]	21.8 ± 0.3 [a]	***	***
b*	7.7 ± 0.4 [a]	12.4 ± 0.2 [b]	7.9 ± 0.6 [a]	***	***
a*/b*	3.0 ± 0.1 [a]	2.0 ± 0.03 [b]	2.9 ± 0.1 [a]	***	***
24 h post mortem					
L*	40.5 ± 0.5 [a]	44.4 ± 0.4 [b]	45.7 ± 0.5 [b]	NS	***
a*	22.0 ± 0.3	22.6 ± 0.2	21.4 ± 0.2	***	NS
b*	6.6 ± 0.2 [a]	7.6 ± 0.7 [b]	8.2 ± 0.3 [b]	NS	**
a*/b*	3.4 ± 0.1 [a]	3.1 ± 0.2 [a]	2.6 ± 0.1 [b]	*	***
6 d post mortem					
L*	40.4 ± 0.5 [a]	43.5 ± 0.5 [b]	43.6 ± 0.5 [b]	$P = 0.07$	***
a*	20.4 ± 0.3	20.1 ± 0.2	20.9 ± 0.3	*	NS
b*	6.1 ± 0.2 [a]	6.0 ± 0.3 [a]	7.0 ± 0.1 [b]	NS	*
a*/b*	3.7 ± 0.07 [a]	3.4 ± 0.2 [a]	3.0 ± 0.08 [b]	NS	*

IFM: intramuscular fat; L*, a*, b*: trichromatic coordinates.
[1] Significance level of the effect, NS: $P > 0.10$; *: $P < 0.05$; **: $P < 0.01$; ***: $P < 0.001$;
[abc] Means lacking a common superscript differ significantly at $\alpha = 0.05$.
None of the interactions between the effects of slaughter series and colour class were significant.

series and colour class, for any of the traits presented in Table I. The breast muscles from the pale group were significantly heavier than those from the normal one, with the magrets from the intermediate colour group showing an intermediate weight. Drip loss differed significantly between the groups but the link with colour was not very clear since muscles from the intermediate group showed a significantly lower drip than those from the normal group, with the pale magrets showing intermediate values for this trait. The breast muscles from the intermediate and pale groups contained significantly more fat than those from the normal group. Trichromatic coordinates L* (luminance) and b* (yellowness) of magrets at 24 h post mortem were significantly and positively correlated with the content of intramuscular fat (Fig. 1).

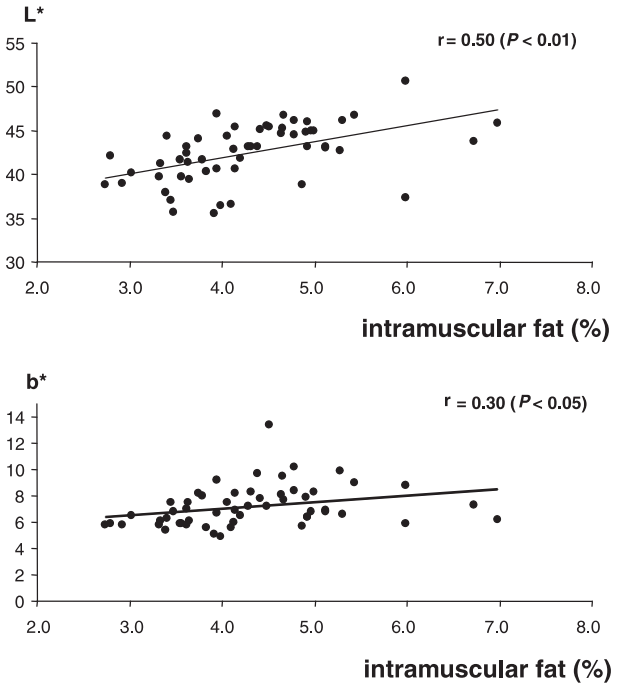

Figure 1. Relationships between the breast muscle content of intramuscular fat and the luminance (L*) and yellowness (b*) measured at 24 h post mortem.

The colour groups created subjectively at 24 h post mortem corresponded to breast meat showing significantly different colour coordinates as early as 4 h post mortem (Tab. I). However, only the luminance at 4 h post mortem (L*) was higher in the pale group. At 24 h post mortem, the magrets from the intermediate and pale groups showed significantly higher L* and b* than those from the normal group. In addition, the palest magrets showed a significantly lower a*/b* ratio than the two other groups. The differences in the luminance were still present at 6 days post mortem. However, the b* in magrets from the intermediate group was not significantly different from that measured in the normal group. This was mainly due to a decrease in b* between 1 and 6 days post mortem in the intermediate group, whereas the normal group showed a stable value for this trait.

Average trichromatic coordinates, metmyoglobin content and Thio Barbituric Acid Reactive Substance (TBA-RS) index did not differ significantly between the two subgroups of normal (n = 5) and pale (n = 5) breast muscles, after 2, 3 and 6 days post mortem (Fig. 2).

4. DISCUSSION

In the studied sample, breast muscle colour measured objectively and subjectively at 24 h post mortem, showed a wide variability. As much as 22% of the magrets showed a drastic colour alteration with a very pale appearance combined to a marked yellow tint.

The visually assessed paleness was associated with higher luminance (L*) and

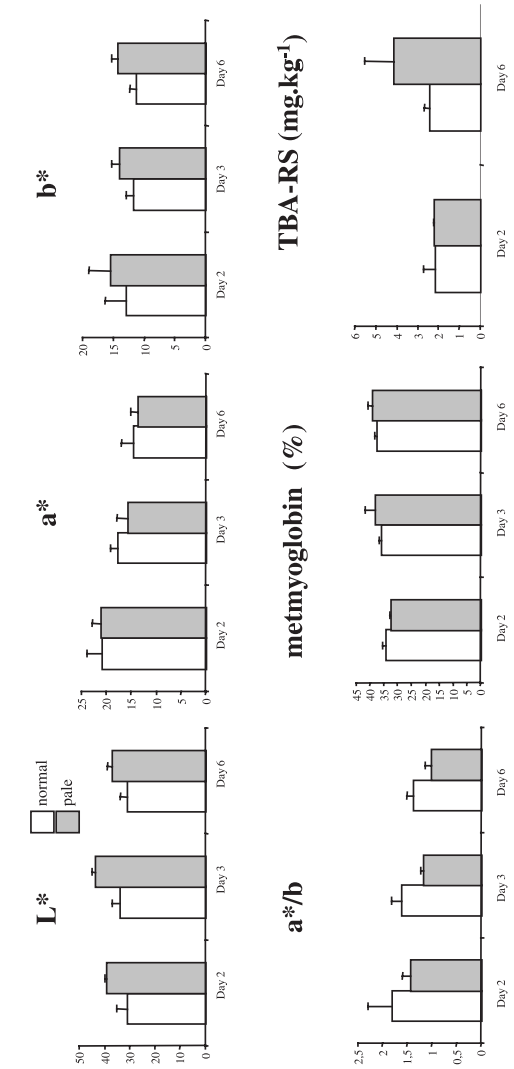

Figure 2. Average trichromatic coordinates, metmyoglobin content and Thio Barbituric Acid Reactive Substance (TBA-RS) index in a subgroup of normal (n = 5) and pale (n = 5) breast muscles, after 2 (d 2), 3 (d 3) and 6 (d 6) days post mortem.

yellowness (b*) and a lower a*/b* ratio than those measured on normal muscles. It should be emphasised that these differences were expressed at 24 h post mortem and their magnitude did not change during the 5 days of storage at +4 °C under an oxygen permeable film. This might suggest that the breast muscles classified as pale at 24 h post mortem, showed a higher myoglobin oxidation since their a*/b* ratio was significantly lower than that of normal muscles. Other observations from the present study did not, however, support this assertion. Myoglobin oxidation should be accompanied by a decrease in redness (a*), which was not observed here. In addition, the measurements carried out on the small (n = 5) subgroup of magrets did not show significant differences in the percentage of metmyoglobin between normal and pale muscles. The oxidation of meat lipids and pigments is known to be closely related [4, 6]. In the present case, the TBA-RS index did not differ significantly between the two subgroups at 24 h post mortem, whereas at that time, the colour differences were already large in the major sample. Therefore, it is unlikely that colour differences could be due to variations in the intensity of myoglobin and/or lipid oxidation. However, due to the low number of birds (n = 5) in the two subgroups, these hypotheses require confirmation.

Although the link between the colour group and the pH value at 20 min post mortem was not linear (the intermediate group showed a lower pH_{20} than the pale group), our results show that an increased rate of post mortem pH fall is associated with a paler colour of duck magrets. Indeed, pH_{20} was lower in the intermediate and pale group, than in the normal one. The effect of the rate of post mortem pH fall on meat colour has been extensively studied in PSE meat from other animal species such as pork [10]. The observed variability in colour cannot, however, be undoubtedly attributed to the incidence of PSE meat in duck muscle since the observed differences in drip loss between the colour groups were not consistent with the differences in the rate of pH fall in post mortem muscle: the normal group showed the highest pH_{20} with the highest drip loss.

The present results suggest that the palest muscles were also the heaviest. This result is in agreement with previous observations obtained on Muscovy ducks [3] where the selection for increased muscle mass has induced paler breast meat.

According to Salichon et al. [12], the increased luminance and yellowness of breast muscle in response to overfeeding, would be primarily due to the increased level of intramuscular fat. Our results partly agreed with this observation since a significant and positive relationship between the colour coordinates L*, b* and the level of intramuscular fat was noted. The difference in colour between the intermediate and the pale groups cannot, however, be explained by the level of intra muscular fat (5.11 and 4.60% on average for the intermediate and pale groups, respectively).

5. CONCLUSIONS

These preliminary results indicate that the colour of duck magrets may show a wide variability and more specifically, a noticeable percentage of muscles can show a marked alteration of colour with a very pale appearance. The mechanisms underlying this variability deserve, however, further investigation. In addition, it seems worthy to evaluate the impact of colour alteration on the consumer's perception of this product.

REFERENCES

[1] Auvergne A., Desforges M., Fernandez X., Gestes G., Babilé R., Croissance et performances de gavage de trois croisements de canards mulards, in: Proceedings of the 5es

Journées de la Recherche sur les Palmipèdes à Foie Gras, Pau, France, 2002, pp. 46–49.

[2] Babilé R., Auvergne A., Dubois J.P., Leprettre S., Manse H., Comparaison de différents systèmes de production de l'oie gavée : Incidences sur la composition des muscles pectoraux et la qualité des magrets séchés, in: Proceedings of the 4es Journées de la Recherche sur les Palmipèdes à Foie Gras, Bordeaux, France, 2000, pp. 151–154.

[3] Baeza E., De Carville H., Salichon M.R., Marché G., Leclercq B., Effects of selection over three and four generations on meat yield and fatness in Muscovy ducks, Brit. Poult. Sci. 38 (1997) 359–365.

[4] Faustman C., Cassens R.G., Schaeffer D.M., Buege D.R., Scheller K.K., Improvement of pigment and lipid stability in Holstein steer beef by dietary supplementation with vitamin E, J. Food Sci. 54 (1989) 485–486.

[5] Folch J., Lee M., Sloane-Stanley G.H., A simple method for the isolation and purification of total lipids from animal tissue, J. Biol. Chem. 226 (1957) 497–509.

[6] Gatellier P., Anton M., Chraiti F., Renerre M., Relationships between lipid oxidation, antioxidant enzyme activities and colour stability in raw beef during storage, in: Proceedings of the 38th Int. Cong. Meat Science Technol., Clermont-Fd, France, 1992, pp. 495–498.

[7] Krzywicki K., Assessment of relative content of myoglobin, oxymyoglobin and metmyoglobin at the surfaces of beef, Meat Sci. 3 (1979) 1–8.

[8] Lynch S.M., Frei B., Mechanisms of copper- and iron-dependent oxidative modification of human low density lipoprotein, J. Lipid Res. 34 (1993) 1745–1751.

[9] Mercier Y., Gatellier P., Viau M., Rémignon H., Renerre M., Effect of dietary fat and vitamin E on colour stability and on lipid and protein oxidation in turkey meat during storage, Meat Sci. 48 (1998) 301–318.

[10] Monin G., Évolution post-mortem du tissu musculaire et conséquences sur les qualités de la viande de porc, J. Rech. Porcine France 20 (1988) 201–214.

[11] Salichon M.R., Baeza E., Leclercq B., Biochemical characteristics of Muscovy duck breast, Sci. Alim. 17 (1997) 227–233.

[12] Salichon M.R., Guy G., Rousselot-Pailley D., Wacrenier N., Blum J.C., Baeza E., Influence d'une supplémentation en vitamine E sur la qualité de la viande (Filet et Magret) et du foie gras chez le canard mulard, in: Proceedings of the 3es Journées de la Recherche sur les Palmipèdes à Foie Gras, Arcachon, France, 1998, pp. 127–131.

[13] SAS Institute, SAS® User's Guide for personal computers, Release 6.03, SAS Institute Inc., Cary, NC, 1989.

[14] Setiawan I., Études comparatives de différents types génétiques de canards mulards, Thèse de Doctorat, Institut National Polytechnique de Toulouse, 1994, 270 p.