Meat color alterations are not necessarily associated with other PSE-like meat defects in turkey

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SUMMARY

The aim of the present study is infirming, or not, that it is possible to sort turkey breast meat on the basis of color to detect meat with quality defects. Two separate trials were performed on male (n=20) and female (n=20) BUT9 turkeys reared and killed under commercial conditions. At 24h post-mortem, breast muscles were first sorted by the manager of a processing plant according to their subjective color and classified into 2 groups: pale or normal meat. Then, the objective color was measured in CIELAB system. In both trials, at 24h post-mortem, L* values were significantly different between the pale and normal groups (54.0 ± 1.6 and 48.5 ± 2.8; 53.3 ± 1.0 and 48.3 ± 2.4 for females and males, respectively). Values of ultimate pH were not significantly different between the 2 groups and they were in a normal range (around 5.6). Throughout the storage period, L* values were higher in the pale group. No significant differences between the 2 groups were reported for drip loss, thawing loss and cook loss. Napole yield was not significantly different between normal and pale meat in both trials. No significant differences were found in shear force values between the 2 groups. Finally, even though large differences in L* values were reported between the normal and pale group, other meat quality properties (water holding capacity and tenderness) were not affected. In the present study, we can conclude that it is not possible to detect PSE meat only on the basis of a paler color of turkey breast meat.

Keywords: Color, meat, PSE, turkey, quality.

RéSUMÉ

Les altérations de couleur ne sont pas nécessairement associées aux autres défauts de type PSE-like chez la dinde.

L’objectif de cette étude est de confirmer ou non la possibilité de trier des filets de dinde sur la base de la couleur pour détecter les viandes présentant des défauts de qualité. Deux expériences séparées ont été réalisées sur des dinde mâles (n=20) ou femelles (n=20) BUT9 élevés et tués dans des conditions commerciales. A 24h post-mortem, les filets ont d’abord été triés par le responsable de l’usine de découpe en fonction de leur couleur subjective et classés en 2 groupes : viande normale ou pâle. Ensuite, la couleur objective de la viande a été mesurée dans le système Lab. Dans les 2 expériences, à 24h post-mortem, les valeurs de L* sont significativement différentes entre le groupe normal et pâle (54.0 ± 1.6 et 48.5 ± 2.8 ; 53.3 ± 1.0 et 48.3 ± 2.4 pour les femelles et les mâles respectivement). Les valeurs de pH ultime ne différent pas entre les 2 groupes. Au cours de la période de stockage, les valeurs de L* sont significativement plus élevées dans le groupe des viandes pâles. Par contre, aucune différence significative n’est mise en évidence pour les pertes à la conservation, à la décongélation et à la cuisson. Le rendement Napole ne diffère pas non plus entre les 2 groupes. Les forces de cisaillement sont également similaires entre les 2 groupes. Finalement, malgré de grandes différences de valeurs de L* entre les viandes pâles et normales, les autres propriétés organoleptiques et sensorielles de la viande ne sont pas affectées. Dans cette étude, nous pouvons conclure qu’il ne serait pas possible de détecter les viandes PSE uniquement sur la base d’une couleur plus pâle chez la dinde.

Mots-clés : Couleur, viande, dinde, PSE, qualité.

Introduction

Pale, soft, exudative (PSE) syndrome leads to meats, which have paler color, higher toughness and lower water-holding capacity (WHC). In pork, this phenomenon was described a long time ago and the genetic origin is well established [8]. In poultry, PSE meats have been reported quite recently [turkey: 3, 4; chicken: 23, 25]. Several factors such as genetic strains, halothane sensitivity, thermal stress just prior to slaughter or during animal rearing, and stunning methods that could be involved in this phenomenon were studied. Unfortunately, these studies were not conclusive.

As the origin of PSE meat in poultry is unknown, objectives of many researches were to find a way to detect PSE meat in order to separate it from normal meat. The most adapted criterion is the muscle pH value measured early post mortem (15-20 min, for instance). However, such a measurement is hardly conceivable in a processing plant because it is time consuming and cannot be performed automatically. In consequence, several researchers reported studies to find out other criteria to sort PSE-like meat. The most widely used is the color of meat and especially L* value [1, 2, 3, 4, 11, 18, 23, 25]. Color was generally chosen because it is fast, non-destructive and easy to use in a commercial environment. BARBUT [1, 2, 4] suggested to classify as PSE every turkey breast meat with L* values higher than 52 at 24h post mortem. With such a cutoff value, the occurrence of PSE meat includes between 5 and 30% of the slaughtered turkeys in North America [2, 3, 11]; unfortunately, no such survey is available in Europe.

PSE meats should include the apparition of the 3 quality alterations: color, texture and WHC. However, in literature, all of them are hardly met. Indeed, relationships between L* values and WHC on one hand and between L* values and ultimate pH (pHu) on the other hand are well-known in turkey meat as well as in chicken one. Indeed, Mc CURDY et al. [11] and BARBUT [3] reported negative correlation between L* values and WHC (-0.61 and -0.47 respectively). Moreover, BARBUT [1, 2, 3] and Mc CURDY et al. [11] reported a negative correlation between L* values and pHu (-0.71, -0.76, -0.79 and -0.62 respectively).

All the studies about detecting poultry PSE meat using color measurements were only performed in North America. In the present study, we wonder whether, in Europe, such correlation between L* values and meat quality parameters can also be found. To achieve this goal, we worked in a commercial processing plant where the manager reported turkey breast meat color alteration. He first sorted turkey breast muscles into pale or normal according to his experience. Then, the breast meat color was measured. We worked in a commercial processing plant according to their subjective color and classified into 2 groups: pale (n=10 for males and n=10 for females) or normal (n=10 for males and n=10 for females) meat. Then, the objective color was measured in CIELAB system with a Minolta chromameter as described below.

Slices (137 ± 27g) were also cut from the widest part of breast muscle (Pectoralis major) for different meat quality measurements during a 9-day storage period at 4°C.

Material and Methods

ANIMALS

Two separate trials were performed on males (n=20) and females (n=20) BUT9 turkeys reared under commercial conditions. The animals were slaughtered at their respective commercial age: 13 weeks for female and 16 weeks for male in a conventional slaughter house. At 24h post mortem (D1), breast muscles were collected and sorted by the manager of the commercial processing plant according to their subjective color and classified into 2 groups: pale (n=10 for males and n=10 for females) or normal (n=10 for males and n=10 for females) meat. Then, the objective color was measured in CIELAB system with a Minolta chromameter as described below.

COLOR MEASUREMENTS

The color of the meat was measured at D1, D3, D6 and D9 on the slices cut at D1 with a Minolta CR-300 chromameter [19]. The instrument was set to measure CIE L*, a*, b* using illuminant D65.

PH MEASUREMENTS

At D1, pHu values were measured with a portable pH meter equipped with a probe (M92136, Fisher Bioblock Scientific, Illkirch, France).

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WATER-HOLDING CAPACITY

Drip loss was evaluated on slices harvested at D1. Individual slices were stored in a polystyrene tray covered by a standard catering film (air permeable) at 4°C. They were weighed at D3, D6 and D9. Drip loss is expressed in percent of the weight at D1 [10].

After 9 days of storage, the slices were weighed (pre-thaw weight) and frozen. They were kept at −20°C for 3 weeks. Then, they were allowed to thaw overnight at 4°C and re-weighed (pre-cook weight). The entire slice was then vacuum packaged and cooked in a 80°C water bath for 15 min [14]. After cooking, samples were allowed to equilibrate at room temperature in a water bath, rapidly wiped and weighed. Thaw loss was expressed as a percentage of the pre-thaw weight. Cook loss was expressed as a percentage of the pre-cook weight.

NAPOLE YIELD

Napole yield was determined using the procedure described by NAVEAU et al. [15]. Briefly, one hundred grams of fresh muscle were cut into pieces of about 1 cm², placed in brine (136 g nitrited salt/l, 0.9% nitrite in the salt) and stored at 4°C for 24h. The mixture was cooked for 15 min in boiling water and drained for 2.5h. Napole yield was determined as the percentage of final weight of cooked meat relative to the initial weight of meat.

TEXTURE

Objective texture was measured on raw meat at D2 and on cooked meat. It was determined using a Warner-Bratzler single blade placed on a universal testing machine (MTS®, Synergie 200). Adjacent 1.0 cm wide strips were cut from the medial portion of the slice, parallel to the longitudinal axis of the myofibres, and sheared as described by HONIKEL [10]. Reported values are the means of 4 trials per sample.

STATISTICAL ANALYSIS

Data was analyzed using the general linear model procedure of Minitab®, software [13]. A one-way analysis of variance was performed to compare normal and pale group values.

Results and discussion

L* values were measured during a 9-day storage period (Table 1). In both trials, at 24h post mortem, L* values were significantly different between pale and normal groups. The difference in L* values at D1 was about 5 points. This difference remained throughout the storage period regardless of sex. In pale meat group, L* values were always higher than 52 and reached a maximum value of 55 at D9. BARBUT [1, 2, 4] suggested that poultry meat that have L* values greater than 52 should be classified as PSE. In this study, and according to BARBUT [1, 2, 4], our pale meat is supposed to be consi-
 COLOR ALTERATIONS AND PSE TURKEY MEAT

...dered as PSE-like. Nevertheless, we will demonstrate that as other meat defects normally associated with PSE meat characters are not different between pale and normal meat, this color cutoff point cannot be simply applied.

The $a^*$ values, regardless of sex, remained significantly lower for the pale meat throughout the storage period (Table 1). This could mean that when pale meat was selected, the criterion was not only a paler color of meat but also a less red meat. In the case of PSE meat, several studies also reported lower $a^*$ values for fast glycolyzing turkey muscles compared to normal glycolyzing ones [20, 6, 9, 14].

Concerning yellowness ($b^*$) values, there was almost no difference between the 2 groups whenever color evaluation was performed (Table 1). Yellowness values are not well documented in literature about PSE meat so no clear conclusions can be drawn about these parameters.

Ultimate pH ($pH_u$) value is one of the key factors for the determination of meat quality. In the present study, in both male and female, $pH_u$ values were not significantly different between pale and normal meats. They also were in a normal range (Table 2). In the case of PSE meat, it is generally admitted that the rate of post mortem pH decline is increased but $pH_u$ values remain similar to those of normal meat [5, 17, 22].

Relationships between $L^*$ values and $pH_u$ and/or early post mortem pH are well-known in turkey meat as well as in chicken one. However, in literature, it is often difficult to know whether some differences observed in $L^*$ values are due to a higher rate of pH decline, or to differences in $pH_u$ values, or both. Indeed, some authors reported a negative correlation between $pH_u$ and $L^*$ values (–0.71, –0.71, –0.62 and –0.76 for 1, 11, 23 respectively). In both turkey and chicken, SAMS et al. [21] reported lower $pH_u$ (around 0.4 pH unit difference) for pale breast meat compared to normal meat. On the contrary, NORTHCUIT [16] selected pale and normal breast meat on a color basis and reported no differences in $pH_u$ values. In the present study, no differences in $pH_u$ values were pointed out. From this, it can be concluded that observed differences in $L^*$ values were not due to higher amplitude of pH decline during post mortem events.

If the color of the meat is an extremely important sensory characteristic which largely influences consumer choices while buying meat, tenderness is also a very important sensory property of meat which greatly influences the perception of the consumer while eating meat. In PSE syndrome, tenderness of meat is altered: raw meat is softer and cooked meat tougher [7, 12]. In the present study, tenderness of meat was evaluated using Warner Bratzler shear force test on raw and cooked meat (Figure 1). In both case, no significant differences were found in shear force...
values between pale and normal meat. NORTHCUTT [16] also reported no differences in shear stress or shear strain of meat batter from pale or normal turkey meat. Conversely, BARBUT [1] reported a negative correlation between L* values and gel strength indicating that pale meats have a lower gel strength. This lower gel strength could be explained by the lower pHu of pale meat [1]. In our study, tenderness of meat does not seem to be influenced by the paler color.

Color and texture are mainly considered by consumers whereas WHC is the most concerning issue for meat processing industry. WHC concerns mainly drip loss (during storage) and cook loss, but also in many cases, thawing loss and processing yields. Concerning PSE meats, either in pork or in poultry, it is generally admitted that WHC decreases. In the present study, WHC was evaluated with two different methods. First, drip loss was measured during a 9-day storage period, then slices were frozen and thawing loss was evaluated. Finally, slices were cooked to measure cook loss. No significant differences were reported between pale and normal meats for drip, thawing and cook losses (Figure 2A). SAMS et al. [21] and Mc CURDY et al. [11] reported no significant correlation between L* values and cook loss in turkey meat. On the contrary, many studies reported significant correlations between L* values and WHC (-0.71 [1]) or L* values and cook loss (+0.7 [1]). BARBUT [2] also pointed out a very strong correlation (-0.87) between pHu and WHC. This negative correlation means that, the lower the pHu, the higher the WHC. This relationship was unexpected because, in muscle, when pHu is low, it is closer to the isoelectric point of muscle proteins, which would lead to a lower WHC of meat. In our study pHu values were not different between the 2 groups. This could explain the lack of differences in WHC. Moreover, the correlation between L* values and WHC was not significant (data not shown). Furthermore, in pork, WARRIS and BROWN [24] and VAN LAACK et al. [22] reported that L* values and WHC were poorly linked. Only one third of WHC variations were explained by variations in L* values [22] leading these authors to conclude that it was not possible to use only L* values to detect exudative meats.

We also evaluated the processing ability of pale and normal meats with Napole yield (Figure 2B). In the present study, the processing yield was not significantly different between normal and pale meat in either sex. NORTHCUTT [16] reported no difference in processing ability (meat batter) between normal and pale turkey meat. WOELFEL and SAMS [25] also found no difference in marinade uptake and retention between pale and normal chicken fillets.

Finally, even though large differences in L* values were reported between normal and pale group; other meat quality properties (tenderness and WHC) were similar between the two types of meat. From this study, the use of cutoff point for L* value was not appropriate to sort different meat qualities in turkey. As a consequence, we can conclude that sorting breast meat on a L* value basis is not adapted to the detection of PSE-like in turkeys. This point might be comforted in a more large study.

### TABLE 1: Color values of slices from Pectoralis major during a 9-day storage period at 4°C (mean ± SD, n = 10)

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Male</th>
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<tr>
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<td>**</td>
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</tr>
<tr>
<td>Normal</td>
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</tr>
<tr>
<td>D1</td>
<td>48.49 ± 2.79</td>
<td>50.65 ± 2.68</td>
</tr>
<tr>
<td>D3</td>
<td>50.52 ± 2.81</td>
<td>49.14 ± 2.30</td>
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<tr>
<td>D6</td>
<td>49.28 ± 2.43</td>
<td>51.45 ± 2.95</td>
</tr>
<tr>
<td>D9</td>
<td>51.04 ± 3.71</td>
<td>50.12 ± 2.21</td>
</tr>
<tr>
<td>L* Pale</td>
<td>53.98 ± 1.64</td>
<td>54.86 ± 2.12</td>
</tr>
<tr>
<td>Statistics</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Normal</td>
<td></td>
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</tr>
<tr>
<td>a* Pale</td>
<td>5.54 ± 1.16</td>
<td>5.55 ± 1.61</td>
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<tr>
<td>Statistics</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Normal</td>
<td>1.13 ± 1.14</td>
<td>4.99 ± 1.19</td>
</tr>
<tr>
<td>b* Pale</td>
<td>1.65 ± 0.36</td>
<td>4.56 ± 1.11</td>
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<tr>
<td>Statistics</td>
<td>NS</td>
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NS: non significant (P > 0.05), *: P < 0.05, **: P < 0.01, ***: P < 0.001. Values between males and females and the interaction sex by group never differ whatever the time and color parameter considered.

### TABLE 2: Values of ultimate pH (pHu) of pale and normal turkey breast meat (mean ± SD, n = 10)

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Male</th>
</tr>
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<tbody>
<tr>
<td>Normal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.72 ± 0.06</td>
<td>5.75 ± 0.28</td>
<td></td>
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<tr>
<td>Pale</td>
<td>5.67 ± 0.08</td>
<td>5.54 ± 0.16</td>
</tr>
<tr>
<td>Statistics</td>
<td>NS</td>
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NS: non significant (P > 0.05)
Acknowledgement

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References