INFLUENCE OF MAP STORAGE BY 15 DAYS ON LOIN pH AND COLOUR FROM TWO CONTRASTING PORK TYPES

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Abstract – This paper describes the pH and objective colour parameters of loin slices from two contrasting phenotypes (high vs. low marbling) during modified atmosphere packaging (MAP) storage by 15 days. High marbled pork loin slices showed increased pH from 10 days of MAP storage onwards while the lean pork showed similar pH over the 15 days of storage. High marbled pork showed a delay in the increase of lightness and redness compared to lean loin slices stored in MAP by 15 days. These characteristics may allow longer good visual appeal in high marbled than in lean loin slices, but meat pH remained greater in high marbled than in lean loin slices.

Key Words – Lightness, redness, technological meat quality.

I. INTRODUCTION

Visual appearance characteristics (i.e., colour, subcutaneous fat content, marbling, drip loss) are intrinsic quality cues highly related with consumers' perception of meat quality [1]. Increasingly, red meat for retail display is being prepared and packaged centrally rather than at retail stores. Hence, several packaging conditions have arisen, including modified atmosphere (MAP).

In pork, oxygen-free packaging results in extended shelf-life while high-oxygen packaging improves the colour appearance for a limited time. The most common gas mixture for retail-ready fresh pork contains approximately 70% O_2 and 30% CO_2, which gives the product a bright-red colour [2] that is attractive to the consumer.

The market provides a variety of pork loins with contrasting attributes related to meat colour, marbling, and tenderness, which may differ in their retail response during MAP storage. Hence, this study aimed to evaluate the pH, objective colour parameters and tenderness of loin slices from two contrasting phenotypes (high vs. low marbling) during MAP storage by 15 days.

II. MATERIALS AND METHODS

Loin sampling

A total of 112 finishing pigs from a purebred Duroc population (Selección Batallé, Riudarenes, Girona, n=72 barrows with 201±0.4 days of age; high marbled) and a contrasting crossbred population derived from Pietrain sires and Duroc x Landrace dams (n=40 gilts with 193±0.5 days of age; lean) were used.

The pigs were stunned using CO_2 (88%) (Butina ApS, Holbaek, Denmark), exsanguinated, scalded, skinned, eviscerated, and split down the midline. Backfat thickness between the last 3rd and 4th ribs was estimated by using an on-line ultrasound automatic scanner (Autofom®, SFK-Technology, Herlev, Denmark).

The carcasses were refrigerated by graded reduction of their internal temperature: 16 ℃ (1st hour post-mortem), 8 ℃ (2nd hour), 4 ℃ (3rd hour), 2 ℃ (4th hour) and 2 ℃ (5th hour), keeping approximately 4 ℃ until the end of the 20-h period. The ultimate pH at 24 h post-mortem was measured at *Semimembranosus* muscle with a pH-meter equipped with a spear-tipped probe (Testo 205, Testo AG, Lenzkirch, Germany). Then, carcasses were processed according to commercial standards.

A section of approximately 400 g of *Longissimus thoracis* muscle was excised at the 3th-4th last rib area, it was placed in individual plastic bags and it was vacuum-packaged at 4 °C for transportation to laboratory (3 h away). The day after, the loin sample was sliced into six parts to measure drip loss and tenderness at day 1, and meat colour and pH at 1, 5, 10 and 15 days of storage.

Loin packaging in MAP

Pork loin slices were placed (in groups of 3) on polypropylene trays (9.5 x 13.5 x 2.5 cm) that were sealed with a twice mold modified atmosphere packaging machine (ILPRA, Model Basic VG) using a barrier film after filling with a gas mixture (70 %O_2/30%CO_2; Abelló Linde S.A, Barcelona, Spain). The packages were evacuated using a 700 mm Hg vacuum. The trays were kept in dark at 4 ºC for 1, 5, 10 or 15 days and they were sequentially opened for pH and colour measurement.

Drip loss and tenderness

Drip loss was determined through the use of special meat containers [3] that were filled with a circular loin sample (approximately 6 g) and kept at 4 ºC during 24 h. Drip loss was calculated as the percentage of initial sample weight.

The loin samples analysed for tenderness by cutting them parallel to the long axis of the muscle fibres into rectangular cross-section slices of 10 × 10 mm and 30 mm length. Parallelepipeds (4/slice) were sheared perpendicular to the fibre orientation with a Warner-Bratzler device attached to a texture analyser TA-TX2 (Stable Micro Systems Ltd, Surrey, UK) equipped with a 5-kg load cell and a crosshead speed of 2.5 mm/s.

Meat colour and pH

The *Longissimus thoracis* muscle colour was measured on the polypropylene trays after 30 min of blooming the inner surface with a Konica Minolta CM-700d spectrophotometer (Konica Minolta Sensing Inc., Osaka, Japan) in the CIELAB space17 with a measured area diameter of 8 mm, including specular component and a 0% ultraviolet, standard illuminant D65, which simulates daylight (colour temperature 6504 K), observer angle 10º and zero and white calibration. The Commission Internationale de l'Éclairage (CIE) lightness (L*), redness (a*), and yellowness (b*) colour-space values were reported as the average of two randomly selected readings taken on each slice without any covering film, and mean values were used for statistical analysis.

Meat pH was measured on a 3 g homogenized sample (ground meat) that was blended with 27 ml of distilled water with a homogenizer (1500 rpm during 10 s) [4].

Statistical analyses

The data were analysed with the Jmp Pro 11 statistical software (SAS Institute, Cary, NC, USA). Carcass parameters, ultimate pH, fresh loin drip loss and tenderness were analysed with a standard least squares linear model including pork type (high marbled vs. lean) as fixed effect. Colour attributes and pH during MAP storage were analysed with a linear mixed model including, additionally, the fixed effect of displaying time and its interaction with pork type, whereas the pork loin was considered as a random effect. The level of significance was set at 0.05. Differences ($P<0.05$) between least square means were assessed using a Tukey test.

III. RESULTS AND DISCUSSION

The high marbled pork provided carcasses with greater ultimate pH, weight, backfat thickness but lower loin drip loss and shear force than the lean line pork (Table 1).

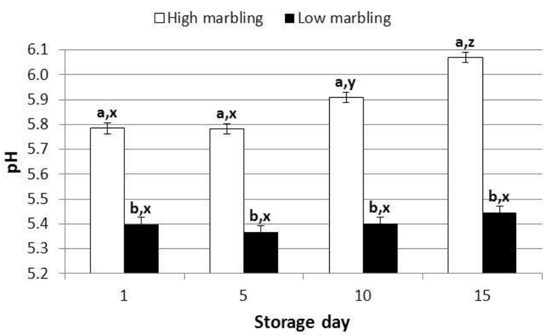
Table 1. LSM for carcass parameters, ultimate pH, fresh loin drip loss and tenderness in high and low marbling groups

Item	High marbling	Low marbling
Carcass weight (kg)	98.8±1.0[a]	95.1±1.3[b]
Back-fat thickness (mm)	37.0±0.6[a]	16.1±0.8[b]
Ultimate pH m. *Semimembranosus*	5.71±0.02[a]	5.61±0.02[b]
Loin drip loss (%)	1.6±0.2[b]	5.7±0.2[a]
Loin shear force (kg)	3.25±0.06[b]	3.48±0.09[a]

[a, b] Differences between groups at $P<0.05$.

The pH of the high marbled loin slices was greater than that of lean loins stored in MAP throughout 15 days (Figure 1). High marbled pork loin slices showed increased pH from 10 days of MAP storage onwards ($P<0.001$) while the low marbled pork showed similar pH over the 15 days of storage ($P>0.05$). Gas mixtures should provide a balance between oxygen-rich atmosphere benefits and CO_2 inhibitory effect on microbial growth [4], which may be greater after pH=6.0 [5]. The current results suggest a greater risk for microbial growth in high marbled pork slices after 10 days of MAP storage compared to low marbled pork, but this hypothesis should be evaluated in further experiments.

Figure 1. Evolution of pH of *L. thoracis* muscle from high and low marbled pork loin slices stored in MAP by 15 days. Means with different letters ([a,b]) within storage day differ significantly (P<0.05). Means with different letters ([x,y,z]) within pork group differ significantly (P<0.05).

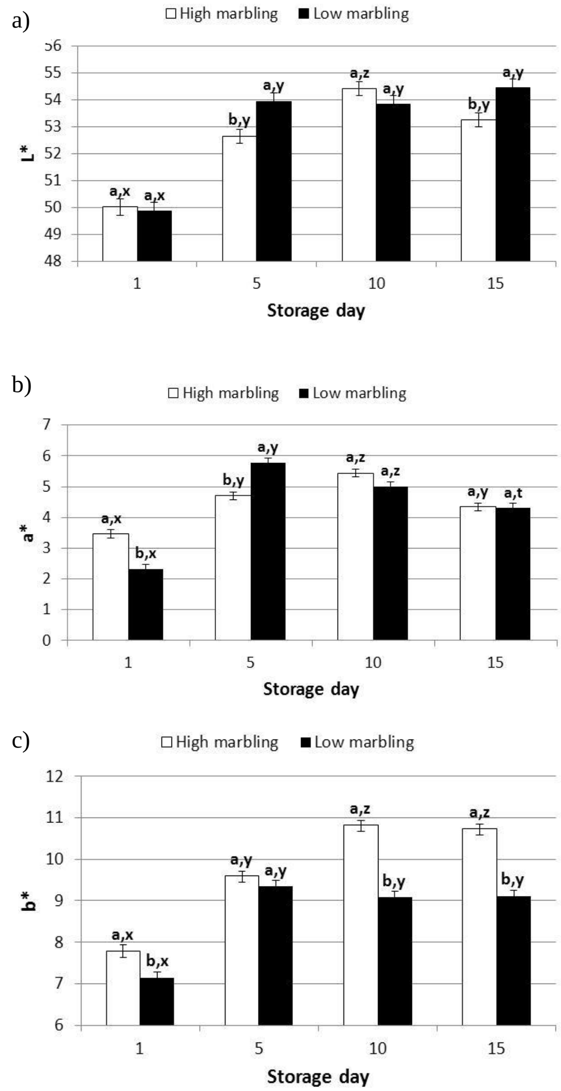


Meat lightness (L*) was similar in both groups at 1 and 10 days, but it was lower in high marbled than in low marbled pork loins at 5 and 15 days of MAP storage (Figure 2a). The evolution of meat lightness differed within each pork type. In high marbled loins, lightness peaked by day 10 of displaying whereas it decreased by day 15 (P<0.001). In lean loins, lightness increased sharply by day 5 (P<0.001) and it remained steady until day 15 of MAP storage (P>0.05).

Meat redness (a*) differed across pork types at 1 and 5 days (P<0.001) but it was similar between them thereafter (P>0.05) (Figure 2b). Within each pork type, meat redness peaked in high marbled loins by day 10 of MAP storage while in lean loins slices it peaked by day 5 (P<0.001). Oxygen-rich atmosphere package increased redness in both pork types, but the peak was delayed in high marbled compared to low marbled loin slices. After 15 days of MAP storage the redness decreased below 5 in both pork types, in agreement with previous reports [4].

Meat yellowness (b*) was greater in high marbled loins than in lean loins (day 1: P<0.05, days 10 and 15: P<0.001), except at day 5 of MAP storage (P>0.05) (Figure 2c). This difference may reflect their divergent intramuscular fat content, as observed elsewhere [6]. Within each pork type, meat yellowness peaked steadily by 10 to 15 days of MAP storage in high marbled loins (P<0.001) whereas in lean loins this rise was detected from day 5 onwards (P<0.001).

Figure 2. Evolution of L* (a), a* (b) and b* (c) scores in *L. thoracis* muscle from high and low marbled pork loin slices stored in MAP by 15 days. Means with different letters within storage day differ significantly (P<0.05). Means with different letters ([x,y,z,t]) within pork group differ significantly (P<0.05).



IV. CONCLUSION

High marbled pork showed a delay in the increase of lightness and redness compared to lean loin slices stored in MAP by 15 days. These characteristics may allow longer good visual appearance in high marbled than in lean loin slices, but meat pH remained greater in high marbled than in lean loin slices. High marbled slices showed a lower shear force compared to lean pork.

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