Influence of two breeds (Belgian Blue and Limousin) and previous storage time on pigment and lipid stability of high-oxygen atmosphere packaged beef

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Introduction

The first impression consumers have of any meat or meat product is its color. Color affects the perception of the meat freshness, and thus influences consumers purchasing decision. Myoglobin is the main component responsible for meat color. The oxidation of myoglobin turns this pigment to metmyoglobin (MetMb), which gives the meat a brown color. Concomitantly, lipid oxidation results in formation of aldehydes, some of them being associated with the development of off flavors even at low concentrations.
As reviewed by Faustman *et al.* [1], myoglobin oxidation and lipid oxidation often appear to be linked and the oxidation of one of these leads to the formation of chemical species that can exacerbate oxidation of the other. In this way, it seems pertinent to study both processes simultaneously.
The Belgian meat sector often complains of a high sensitivity of Belgian Blue beef to oxidation processes, in particular the discoloration of high-oxygen modified atmosphere packaged (MAP) meat previously aged in vacuum conditions.
In this context, the present experiment was conducted to evaluate the effect of two breeds (Belgian Blue *vs*. Limousin) and previous storage time in vacuum conditions on color and lipid stability of meat packaged in high-oxygen atmosphere.

Materials and methods

Samples: Two days after slaughter, four vacuum-packed (VP) striploins from two Belgian Blue cows (7.0 ± 2.4 yr) and four VP striploins from two Limousin cows (6.0 ± 1.0 yr) were supplied by a Walloon slaughterhouse. In the lab, 3 cm thick steaks were cut, vacuum packaged, and stored at −1 °C or +4 °C for up to 60 d. Each 20 d, a part of the samples was repackaged in trays containing a modified atmosphere (MA) – 70 % O_2/30 % CO_2 –, stored 2 d at +4 °C and 5 d at +8 °C (according to AFNOR NF V01-003 standard [2]), and analyzed. *Color (C.I.E. L*a*b* space)*: instrumental color of samples was evaluated 1.5 h after removal from package using a Minolta CM-600d spectrophotometer (11 mm aperture, D_{65} illuminant, 10° observation angle). *MetMb %*: this was calculated using an adaptation of the method of Krzywicki [3] based on the concept of reflectance, measured at the isobestic wavelengths 474, 525, and 572 nm and at 700 nm instead of 730 nm. *Lipid oxidation*: To assess lipid oxidation, TBARS content was measured by spectrophotometric quantification of a complex formed with malondialdehyde (MDA) as described by Raharjo *et al*. [4]. *Fat content*: The fat content was determined by Soxhlet method (ISO 1444:1996) [5]. *Statistical analysis*: Experimental data for each response variable were analyzed by ANOVA using the GLM procedure. Whenever a *post-hoc* test was suitable, Tukey test was performed.

Results and discussion

Color: No spectacular change of color was observed in VP samples during 60 days of storage at −1 °C or +4 °C. However, once these samples were repackaged in trays containing a modified atmosphere, a decrease of the chromaticity a* (redness) was observed over time ($p < 0.05$). Even if Limousin samples presented greater initial a* values (23.4 ± 1.5) than Belgian Blue (17.7 ± 0.6), values of a* from MAP Belgian Blue samples tended to stay longer stable than those from Limousin. In order to evaluate the stability of redness of the samples, chromaticity a* values obtained from MAP striploins were plotted against days of previous storage under vacuum. The absolute values of the slopes obtained for Belgian Blue samples (0.11 and 0.16 for a previous VP storage at −1 °C and +4 °C, respectively) were lower than those obtained for Limousin (0.23 and 0.20 for a previous VP storage at −1 °C and +4 °C,

respectively) confirming that samples from Belgian Blue presented a lower loss of redness than samples issued from Limousin.
MetMb %: As for chromaticity a*, no important changes in MetMb % were observed in VP samples, and MAP samples from Belgian Blue tended to present a higher myoglobin stability until 40 days of previous storage under vacuum ($\Delta_{MetMb\ \%}$ 16.6 ± 2.2 and 23.2 ± 5.9 for a previous VP storage at −1 °C and +4 °C, respectively) than samples from Limousin ($\Delta_{MetMb\ \%}$ 49.7 ± 15.9 and 59.9 ± 9.4 for a previous VP storage at −1 °C and +4 °C, respectively). A comparison of absolute values between samples from both breeds should be done with considerable attention as reflectance measurements are affected by several inherent muscle properties [6].
Lipid oxidation: VP storage at −1 °C provided the best conditions for lipid stability as MDA-equivalent values in these samples remained unchanged during the 60 days of this experiment. Lipids remained stable in vacuum storage at +4 °C during 40 days. Once samples were repacked under modified atmosphere, an effect of previous storage time was noticed ($p < 0.01$).
In order to correlate myoglobin oxidation and lipid oxidation, MetMb % values obtained were plotted against MDA-equivalent values for all the samples of this study. A positive correlation was established ($R^2 = 0.73$), suggesting a link between both phenomena.
Fat content: The fat content was 1.4 ± 0.7 % in meat from Belgian Blue and 4.6 ± 0.8 % in meat from Limousin. The higher amount of fat in meat of Limousin could partially explain its sensitivity to oxidation. However, there are other parameters likely to be involved in the oxidative reactions of meat that still need to be studied more deeply such as MetMb reducing activity (possibly influenced by reducing enzymes, NADH pool and others…) and antioxidant capacity (possibly influenced by α-tocopherol content).

Conclusion

Limousin meat samples of this study presented a higher sensitivity to myoglobin and lipid oxidation than Belgian Blue samples. The higher content of fat in those samples was one of the factors that could explain this higher sensitivity.
Lipid oxidation and myoglobin oxidation appear to be linked, and further studies to understand the interaction between both processes are still needed. An understanding of the oxidative processes and their interaction would provide a basis for explaining quality deterioration in meat and also for developing strategies (e.g. antioxidant supplementation) to maintain sensory qualities.

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References

1. Faustman, C., Sun, Q., Mancini, R. & Suman, S.P. (2010). Myoglobin and lipid oxidation interactions: Mechanistic bases and control. Meat Science 86: 86-94.
2. AFNOR. (2010). Hygiène des aliments – Lignes directrices pour la réalisation de tests de vieillissement microbiologique – Aliments périssables et très périssables réfrigérés, NF V01-003. La Plaine Saint-Denis: Agence Française de Normalisation.
3. Krzywicki, K. (1979). Assessment of relative content of myoglobin, oxymyoglobin and metmyoglobin at the surface of beef. Meat Science 3: 1-10.
4. Raharjo, S., Sofos, J. N. & Schmidt, G. R. (1992). Improved speed, specificity, and limit of determination of an aqueous acid extraction thiobarbituric acid-C18 method for measuring lipid peroxidation in beef. Journal of Agricultural and Food Chemistry 40: 2182-2185.
5. ISO. (1996). Meat and Meat products; determination of free fat content, ISO 1444. Geneva: International Organization for Standardization.
6. AMSA. (2012). Meat Color Measurement Guidelines: Revised December 2012. Champaign: American Meat Science Association.