INFLUENCE OF BREED AND PREVIOUS STORAGE TIME ON COLOR AND LIPID STABILITY OF BEEF PACKAGED IN HIGH-OXYGEN ATMOSPHERE

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Abstract – The aim of this study was to compare the effect of two breeds (Belgian Blue *vs.* Limousin) and previous vacuum storage time on color and lipid stability of meat packaged in high-oxygen atmosphere. Vacuum packaged striploins from Belgian Blue and Limousin cows were stored at −1 °C and +4 °C for up to 60 days and analyzed. Part of these samples were repackaged under modified atmosphere – 70 % O_2/30 % CO_2 – at different times, stored 2 days at +4 °C and 5 d at +8 °C, and then analyzed. The following parameters were evaluated: color (CIE L*a*b*), metmyoglobin %, lipid oxidation (TBARS) and fat content. Color measurement and metmyoglobin % determination showed greater pigment stability in Belgian Blue samples than in Limousin. Belgian Blue also presented higher lipid stability (TBARS). A positive correlation between pigment oxidation and lipid oxidation was highlighted. The greater amount of fat in meat of Limousin could partially explain its higher sensitivity to oxidation. Nevertheless, other factors may be involved in oxidative stability such as metmyoglobin reducing activity and antioxidant capacity. An understanding of the oxidative processes and their interaction would provide a basis for explaining quality deterioration in meat and for developing strategies to maintain sensory qualities.

Key Words – Belgian Blue, Limousin, Modified atmosphere, Oxidation, Vacuum packaging

- INTRODUCTION

The shelf life of fresh meat is mainly limited by the development of pathogenic or spoilage microorganisms, and/or the oxidation of some of its constituents. In order to limit these phenomena, the European legislation allows chilling or freezing, eventually combined with vacuum or modified atmosphere packaging [1].

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, which gives a brown color to meat.

Concomitantly, lipid oxidation results in formation of aldehydes, some of them being often associated with the development of off flavors even at low concentrations [2].

As reviewed by Faustman *et al.* [3], 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 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 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 Belgian Blue cows (7.0 2.4 yr) and four VP striploins from Limousin cows (6.0 1.0 yr) were supplied by a slaughterhouse located in the Walloon Region (Belgium). In the lab, 3 cm thick steaks were cut, vacuum packaged, and stored at −1 °C or +4 °C for up to 60 d (Fig. 1).
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 (in order to simulate distribution

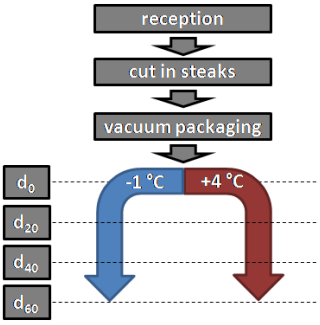

Figure 1. Experimental design for VP samples

conditions at the retail level according to AFNOR NF V01-003 standard [4]), and analyzed (Fig. 2). *Color measurement (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).

Metmyoglobin %:

Metmyoglobin was calculated using an adaptation of the method of Krzywicki [5] based on the concept of reflex attenuance which is the logarithm of the reciprocal of reflectance (measured at the isobestic wavelengths 474, 525, and 572 nm and at 700 nm in the place of 730 nm).
Lipid oxidation measurement: To assess the lipid oxidation, the TBARS content was measured by spectrophotometric quantification of a complex formed with malondialdehyde (MDA) as described by Raharjo *et al*. [6].

Fat content:

The fat content was determined by Soxhlet method (ISO 1444:1996) [7].
Statistical analysis:

Experimental data for each response variable was analyzed by ANOVA using the GLM procedure. Whenever a *post-hoc* test was suitable, Tukey test was performed.

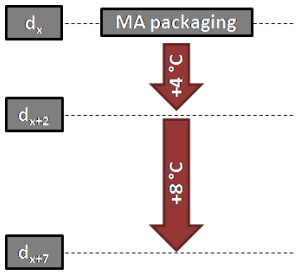

Figure 2. Experimental design for modified atmosphere (MA)-packed samples (x = 0, 20, 40, 60)

- 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 (Table 1).

Even if Limousin samples presented greater initial a* values than Belgian Blue, 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.

Metmyoglobin %:

As for chromaticity a*, no important changes in metmyoglobin % were observed in VP samples, and MAP samples from Belgian Blue tended to present a higher myoglobin

Table 1 Chromaticity a* in striploins

°C*	D	P	Breed			
			Belgian Blue		Limousin	
−1 °C	0	VP	17.7	0.6 ^{a}	23.4	1.5 ^{a}
	20		20.6	1.1 ^{b}	24.1	0.4 ^{a}
	40		19.9	1.3 ^{b}	23.8	0.9 ^{a}
	60		19.8	0.8 ^{b}	23.9	0.5 ^{a}
	0 + 7	MAP	19.9	1.7 ^{ab}	23.5	3.1 ^{a}
	20 + 7		22.2	3.1 ^{a}	22.8	1.8 ^{a}
	40 + 7		17.7	0.7 ^{ab}	14.4	3.0 ^{b}
	60 + 7		14.3	3.8 ^{b}	11.1	2.4 ^{b}
+4 °C	0	VP	17.7	0.6 ^{a}	23.4	1.5 ^{a}
	20		20.1	0.9 ^{a}	23.5	1.0 ^{a}
	40		20.3	1.5 ^{a}	24.9	1.1 ^{b}
	60		18.4	1.6 ^{a}	23.7	1.3 ^{a}
	0 + 7	MAP	19.9	1.7 ^{a}	23.5	3.1 ^{a}
	20 + 7		18.5	3.9 ^{a}	15.3	0.6 ^{b}

40 + 7	15.0	1.8 [a]	12.6	2.1 [bc]	
60 + 7	10.1	1.7 [b]	10.9	1.8 [c]	

°C = (previous) storage temperature under vacuum, D = days, P = package. * Not applicable to day 0 (+ 7). Means and standard deviation are indicated (n = 4). Different letters within the same column (time effect) indicate significant differences.

stability until 40 days of previous storage under vacuum than samples from Limousin (Table 2). 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 such as muscle structure, surface moisture, fat content, pigment concentrations and pH [8].

Lipid oxidation measurement:

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 for vacuum storage at +4 °C during 40 days. Once samples were repacked under modified atmosphere, an effect of previous storage time was brought out (Table 3).

In order to correlate myoglobin oxidation and lipid oxidation, metmyoglobin % values obtained were plotted against MDA-equivalent values for all the samples of this study (Fig. 3). A positive correlation was established, suggesting an eventual correlation between both phenomena.

Table 2 Metmyoglobin % in striploins

°C	D	P	Breed			
			Belgian Blue		Limousin	
−1 °C	0	VP	15.3	1.5 [a]	24.4	1.6 [a]
	20		15.8	1.5 [a]	23.0	1.3 [a]
	40		17.1	1.7 [a]	23.3	1.3 [a]
	60		15.4	0.7 [a]	23.5	2.0 [a]
	0 + 7	MAP	25.0	3.2 [a]	28.8	3.5 [a]
	20 + 7		22.9	6.4 [a]	31.5	2.5 [a]
	40 + 7		29.5	3.3 [ab]	47.1	9.3 [b]
	60 + 7		45.0	12.6 [b]	57.6	6.9 [b]
+4 °C	0	VP	15.3	1.5 [a]	24.4	1.6 [a]
	20		15.2	2.1 [a]	22.4	2.0 [b]
	40		16.2	0.3 [ac]	23.6	1.3 [ab]
	60		15.3	1.3 [bc]	23.8	1.1 [ab]
	0 + 7	MAP	25.0	3.2 [a]	28.8	3.5 [a]
	20 + 7		32.7	10.0 [a]	42.2	2.5 [b]
	40 + 7		32.3	6.4 [a]	46.5	7.6 [bc]
	60 + 7		51.1	10.7 [b]	56.2	5.0 [c]

°C = (previous) storage temperature under vacuum, D = days, P = package. * Not applicable to day 0 (+ 7). Means and standard deviation are indicated (n = 4). Different letters within the same column (time effect) indicate significant differences.

Table 3 MDA-equivalent (mg/kg) in striploins

°C	D	P	Breed			
			Belgian Blue		Limousin	
−1 °C	0	VP	0.09	0.01 [a]	0.17	0.07 [a]
	20		0.12	0.05 [a]	0.19	0.03 [a]

	40		0.11	0.04 [a]	0.18	0.03 [a]
	60		0.13	0.04 [a]	0.27	0.12 [a]
	0 + 7	MAP	0.32	0.14 [a]	0.72	0.34 [a]
	20 + 7		1.00	0.36 [ab]	2.34	0.98 [b]
	40 + 7		1.57	0.36 [bc]	2.70	0.49 [bc]
	60 + 7		2.22	0.61 [c]	3.26	0.73 [c]
+4 °C	0	VP	0.09	0.01 [a]	0.17	0.07 [a]
	20		0.10	0.02 [a]	0.26	0.08 [a]
	40		0.13	0.02 [ab]	0.17	0.04 [a]
	60		0.18	0.04 [b]	0.22	0.04 [ab]
	0 + 7	MAP	0.32	0.14 [a]	0.72	0.34 [a]
	20 + 7		1.05	0.75 [ab]	2.14	0.92 [b]
	40 + 7		0.90	0.66 [a]	2.12	0.46 [b]
	60 + 7		2.00	0.91 [b]	2.66	0.98 [b]

°C = (previous) storage temperature under vacuum, D = days, P = package. * Not applicable to day 0 (+ 7). Means and standard deviation are indicated (n = 4). Different letters within the same column (time effect) indicate significant differences.

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 metmyoglobin reducing activity (possibly influenced by reducing enzymes, NADH pool and others…) and antioxidant capacity.

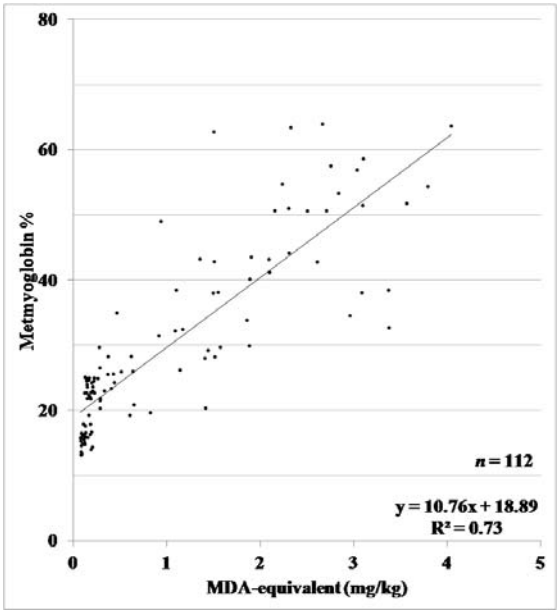

Figure 3. Scatter diagram between metmyoglobin % and MDA-equivalent (mg/kg) of striploins

- 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 highlighted that could explain this sensitivity.

Lipid oxidation and myoglobin oxidation appear to be linked. However, the interacting mechanisms between both processes remain unknown. 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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