Impact of aging technique, muscle and previous vacuum storage time on oxidative stability of beef packaged under high-oxygen atmosphere

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Introduction

Two common approaches for beef aging are wet-aging and carcass-aging. Wet-aging refers to meat aged in a sealed vacuum package at refrigerated temperatures, while carcass aged at controlled temperatures and humidity is defined as carcass-aging. Carcass-aging is an ancient process used nowadays to produce beef characterized by its superior quality. The meat conservability is influenced by its sensitivity to oxidative process which can vary from one muscle to another. The aim of this study was to compare the effect of aging technique (wet-aging *vs.* carcass-aging), two muscles varying in sensitivity to oxidation (*longissimus dorsi vs. rectus femoris*) and previous vacuum storage time on colour and lipid stability of beef packaged in high-oxygen atmosphere.

Materials and methods

After three days of chilling (d_3) and a seven-day wet- or carcass-aging step (d_{10}), *longissimus dorsi* (LD) and *rectus femoris* (RF) muscle cuts from 4 Belgian Blue cows were vacuum packaged (VP) and stored at −1 °C for up to 28 days (d_{38}). At different times, part of these samples was repackaged under modified atmosphere – 70 % O_2:30 % CO_2 –, and stored during 7 days at +4 °C in order to simulate retail conditions. The following parameters were evaluated: colour (CIE L*a*b*), metmyoglobine (MMb) %, fat content, lipid oxidation (TBARS), antioxidant enzyme activities (catalase, glutathione peroxidase and superoxide dismutase) and α-tocopherol content.

Results and discussion

Color: Initial a* values before aging were 20.48 ± 1.89 and 22.43 ± 1.68 for LD and RF respectively, and no significant loss of redness was observed for VP samples during the whole storage. An effect of previous storage time under vacuum conditions was observed for modified atmosphere repackaged (MAP) samples, and an effect of the aging technique was observed for LD samples after 14 days of previous storage under vacuum conditions (Table 1).
Metmyoglobin %: Initial oxidized myoglobin proportion before aging in LD samples was 0.15 ± 3.35 %, and it remained stable after 7 d of aging and 28 d of subsequent storage in vacuum conditions. The initial MMb proportion in RF samples was 0.67 ± 1.09 %. After aging and 28 d of vacuum storage, this value increased to 9.30 ± 2.36 % (wet) and 14.12 ± 8.91 % (carcass). Once samples were repackaged under modified atmosphere, an effect of the previous storage duration was observed. LD carcass-aged samples presented higher pigment stability. For both muscles, wet-aging favored pigment oxidation (Table 2).

Table 1 Chromaticity a* in MAP samples

Muscle	d	Wet-aged	Carcass-aged
LD	10+7	22.36 ± 1.54^{a}	23.46 ± 0.89^{a}
	24+7	$14.96 \pm 5.31^{b\,A}$	$22.61 \pm 1.95^{a\,B}$
	38+7	$9.73 \pm 3.07^{b\,A}$	$17.88 \pm 4.48^{b\,B}$
RF	10+7	18.48 ± 1.28^{a}	18.88 ± 0.93^{a}
	24+7	13.96 ± 4.56^{ab}	17.74 ± 1.75^{a}
	38+7	8.63 ± 1.10^{b}	10.72 ± 1.72^{b}

d = days. Means and standard deviation are indicated (n = 4). Different small letters within the same column (time effect) or capital letters within the same line (aging technique effect) indicate significant differences ($P < 0.05$).

Table 2 Metmyoglobin % in MAP samples

Muscle	d	Wet-aged	Carcass-aged
LD	10+7	7.82 ± 6.62^{a}	3.23 ± 5.75^{a}
	24+7	$57.55 \pm 26.11^{b\,A}$	$6.97 \pm 9.29^{ab\,B}$
	38+7	$73.71 \pm 16.01^{b\,A}$	$34.52 \pm 19.32^{b\,B}$
RF	10+7	25.49 ± 6.95^{a}	26.12 ± 3.31^{a}
	24+7	58.69 ± 26.28^{ab}	34.58 ± 13.10^{a}
	38+7	$85.47 \pm 2.22^{b\,A}$	$77.16 \pm 5.56^{b\,B}$

d = days. Means and standard deviation are indicated (n = 4). Different small letters within the same column (time effect) or capital letters within the same line (aging technique effect) indicate significant differences ($P < 0.05$).

Fat content: Fat content was 2.0 ± 0.8 % in LD and 1.3 ± 0.3 % in RF samples. Polyunsaturated fatty acid proportion was 9.5 ± 5.7 % in LD and 20.3 ± 4.3 % in RF.
Lipid oxidation: The TBARS values for RF samples stayed below the limit of quantification during the whole storage under vacuum conditions. For LD samples, the TBARS values could be quantified after 14 days of storage under vacuum and remained between 0.12 and 0.14 MDA-equivalent mg/kg.
After repackaging under modified atmosphere, an effect of previous storage time was observed for RF samples. Despite its higher fat content, LD samples presented higher lipid stability than RF samples (Table 3).
Antioxidant enzyme activities: The activities of CAT, GSH-Px and SOD were measured in LD and RF samples after aging. Only catalase activity differed according to muscle and this could partially explain the higher predisposition of RF samples to oxidation (Table 4).

Table 3 MDA-equivalent (mg/kg) in MAP samples

Muscle	d	Wet-aged	Carcass-aged
LD	10+7	0.92 ± 0.75	0.57 ± 0.37
	24+7	1.52 ± 0.69	1.02 ± 0.66
	38+7	1.48 ± 0.86	1.30 ± 1.00
RF	10+7	1.34 ± 0.65^{a}	1.04 ± 0.28^{a}
	24+7	1.95 ± 0.97^{ab}	1.57 ± 0.47^{a}
	38+7	3.00 ± 0.98^{b}	3.35 ± 0.43^{b}

d = days. Means and standard deviation are indicated (n = 4). Different letters within the same column (time effect) indicate significant differences ($P < 0.05$).

Table 4 Activities of CAT (U/g), GSH-Px (U/mg) and SOD (U/g) in VP samples after aging (d_{10})

Enzyme	Muscle	Wet-aged	Carcass-aged
CAT	LD	245 ± 26^{a}	248 ± 57^{a}
	RF	190 ± 30^{b}	157 ± 48^{b}
GSH-Px	LD	150 ± 83	105 ± 32
	RF	92 ± 24	85 ± 29
SOD	LD	191 ± 76	321 ± 176
	RF	250 ± 81	281 ± 210

Means and standard deviation are indicated (n = 4). Different letters within the same column (muscle effect) indicate significant differences ($P < 0.05$).

α-tocopherol content: Even if the α-tocopherol content measured after aging was higher in RF samples, it could not prevent this muscle from being more oxidative (Table 5).

Table 5 α-tocopherol content (μg/g) in VP samples after aging (d_{10})

Muscle	Wet-aged	Carcass-aged
LD	2.22 ± 0.63^{a}	2.78 ± 0.33^{a}
RF	4.42 ± 1.21^{b}	4.11 ± 0.76^{b}

Means and standard deviation are indicated (n = 4). Different letters within the same column (muscle effect) indicate significant differences ($P < 0.05$).

Fat content was not directly proportional to α-tocopherol content. As reviewed by Jensen *et al.* (1998), this fact may be explained by a higher capillary supply of RF, which increases the availability of vitamin E, and by the fact of the higher mitochondria content of RF, in which the membrane-bound vitamin E accumulates.

Conclusions

In this experiment, a higher sensitivity to oxidation was observed with wet-aging, and LD showed a higher oxidative stability than RF samples. The length of previous vacuum storage favored oxidation reactions when the samples were repackaged under modified atmosphere. In the case of LD, carcass-aging would allow the extension of shelf-life of 14 days.
Oxidation stability could be associated with the catalase activity in samples, but no association could be found regarding the α-tocopherol content.

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References

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