Argentine beef: antioxidants and colour stability during refrigerated retail display

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Background

Meat colour is the main appearance attribute that affects beef product acceptability and consumer purchasing decision at retail points (*Eikelenboom, 2000*). The colour of the muscle depends on the amount and oxidation/reduction state of myoglobin and meat surface characteristics related to its final pH (*Insausti, 1999*). Colour stability varies according to the muscle type. One explanation for this difference is that muscles contain different balance of anti-oxidative and pro-oxidative compounds that control the oxidation rate of myoglobin (*Trout, 1995*). For example, *Psoas major (PM)* muscle has poor colour stability, which is associated to its high oxidative activity and high myoglobin autoxidation rate (*Renerre & Labas, 1987*). Several studies indicate that the antioxidant α-tocopherol delays myoglobin oxidation and extend the colour stability of display beef (*Faustman, 1996*), but the influence of β-carotene in relationship to this aspect is not well known.

Objectives

To evaluate the influence of different finishing-diets (pasture and feedlot) in relationship with α-tocopherol and β-carotene content and pH values with colour stability during simulated retail display.

Methods

Animals and sample preparation: ten crossbred steers were fed on pasture. Five of them were randomly assigned to remain on this diet, and the other five were finished on feedlot system (without Vitamin E supra-nutritional supplementation) during 110 days until slaughter. The middle part of each *PM* muscle was cut into 10 slices of 2.5 cm. The slices were randomly distributed among the different storage times 1, 3, 5 and 7 days. Two slices of fresh meat were packaged on Polyfoam trays and over-wrapped with an oxygen-permeable polyvinylchloride-film. The samples were exposed under simulated retail display conditions: illumination (1900 Lx) and refrigeration temperature (2 ± 1°C). Metmyoglobin (MMB)%, Hunter Lab colour parameters and pH were determined for all storage times. Determination of α-tocopherol and β-carotene was performed in samples with 1 day of storage. For standardization of retail display, this samples were wrapped in aluminum foil, vacuum packaged and frozen at -20°C until analysis were performed. **Determination of α-tocopherol and β-carotene:** protocols adapted from *Buttriss and Diplock (1984)*. HPLC system consisted of quaternary solvent pump, autosampler and fluorescence and uv-vis diode array detectors. An Alltima C18 column (5μ, 250 x 4.6 mm) was used with Ethanol:Methanol 90:10 as the mobile phase. **pH measurement:** it was performed in meat:destilled water homogenate (1:4) at approximately 20°C by a HANNA pH meter Hi 8314 with an INGOLD type electrode (Metrohm, Herisau, Switzerland). **Colour measurement:** a BYK Gardner Colorimeter with large view area, illuminant D65 and 10°-observer geometry was used. 'L', 'a' and 'b' parameters were measured, over 3 non-overlapped zones of each sample, without over-wrapped film. **Determination of MMB:** The relative MMB% was obtained by reflectance data in 3 different zones of each slice. Then, an average value was calculated for each sample using the ratio of K/S 572 to K/S 525 (*AMS, 1991*). **Statistical analysis:** analysis of Repeated Measures using mixed models (SAS-STAT, SAS Institute, 1996)

Results and discussion

Taking into account that during retail display, light and oxygen favour lipid and protein oxidation, primarily by singlet oxygen mediated reactions, and that β-carotene is known to be a good quencher of singlet oxygen (*Tsuchihashi et al, 1995)*, colour stability in relationship to antioxidant level was studied in meat samples from steers fed with different finishing diets [extensive system-pasture (P) or feedlot (F)]. Moreover *Yin et al. (1997)* reported that in an oxymyoglobin:liposome model, β-carotene at similar level found in P samples of this study (0.52-0.93 with an average of 0.74 μg/g), resulted in delaying oxymyoglobin oxidation. Besides, it has been found that higher levels of vitamin E have beneficial effects on colour maintenance in retail display beef (*Mitsumoto et al, 1997*). The concentration of antioxidants found in P and F samples was different, with higher levels of α-tocopherol and β-carotene in P samples ($p<0.01$) (table II). *PM* P samples had a good correlation ($R^2=0.9507$) when MMB formation and β-carotene initial levels were analysed. However F samples showed a poor correlation (figure 4). This could be explained by the low concentration found in this group that was close to method detection limit. No difference ($p>0.05$) on MMB level was found between P and F samples. As expected, significant increment of MMB% for both treatments, was observed with increasing time on illuminated and refrigerated storage ($p<0.05$) (table III-a). Hunter 'L' (lightness), 'a' (redness) and 'b' (yellowness) values were measured to evaluate objective colour (table I). 'L' and 'a' parameters showed significant difference ($p<0.1$) between P and F samples. Moreover, *'a' value* was higher for P samples after 7 days of display ($p<0.05$). Since there is a strong correlation between 'a' parameter and visual judgment, P samples would have a better consumer's acceptance. 'L' parameter showed higher values for F samples. Besides, L parameter for both treatments (P and F) was not affected by display duration ($p>0.05$). No differences were observed for 'b' parameter between P and F samples, but a significant decrease ($p<0.05$) was observed. These results are in agreement with *Hunt et al., (1995)*. The pH of the muscles, measured at different display times, had acceptable values ranged between 5.40-5.67. Therefore, there were not beef slices with unacceptable colour due to high pH values. This result is in accordance with *Ledward, (1985)* who reported that when the pH values are not higher than 5.80, pH has little influence on MMB formation.

Conclusions

The higher level of antioxidants represented by α-tocopherol and β-carotene found in pasture-finished animals, improved the muscle colour stability in terms of better retention of redness at the end of retail display. Nevertheless, it was not observed an influence of antioxidants on the rate of surface MMB formation.

Literature

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Table I: L, a, b parameters in *Psoas major* muscles
Means with different letter in the same column shows significant difference (Treat.), in the same file shows sig. difference (Time)

Treatments	Parameters	Days of display 1	3	5	7
Feedlot	L	36.7±1.6Aa	37.7±2.3Ab	38.8±2.1Ab	38.5±3.2Ab
	a	16.0±0.9a	14.9±0.9a	12.9±1.5b	10.4±0.8c
	b	16.9±1.2a	16.5±1.1a	16.0±1.1a	14.8±1.0b
Pasture	L	36.6±1.2Aa	35.7±1.6Ba	36.8±1.2Ba	36.1±0.8Ba
	a	15.3±1.8a	15.1±0.8a	13.8±0.7b	11.9±0.9c
	b	17.0±1.0a	16.2±0.7a	16.4±0.5a	15.0±1.0b

Table II: Antioxidants values in *Psoas major* Muscles (µg/g tissue)

Diet / days	α-Tocopherol 1	ß-Carotene 1
Feedlot	0.79 A	0.17 A
Pasture	2.06 B	0.74 B

Table III: (a) Metmyoglobin % and (b) pH of retail displayed slices of Psoas *major* muscles. Means with different letters in the same file shows significant difference (Time)

Treatments	Table IIIa: MMB% Days of display 1	3	5	7
Feedlot	23.5±10.0a	41.0±4.3b	54.8±8.7c	65.8±10.6de
Pasture	23.5±6.0a	41.5±6.4b	53.6±7.4c	65.8±5.8de

Treatments	TableIIIb: pH Days of display 1	3	5	7
Feedlot	5.40 ± 0.05a	5.49 ± 0.07b	5.49 ± 0.11b	5.60 ± 0.14b
Pasture	5.42 ± 0.05a	5.59 ± 0.14a	5.55 ± 0.05a	5.67 ± 0.13a