Colour stability of four bovine muscles packaged under oxygen-depleted atmospheres and low carbon monoxide levels

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Abstract

Steaks from *Gluteus medius m (GM), Longissimus dorsi m (LD), Psoas major m (PM),* and ground beef from *Triceps brachii (TB*) were packed on expanded polystyrene tray and wrapped with polyvinyl chloride film. Four trays of each product were placed in masterpack under anoxic conditions containing T1: 0.2%CO/60.0%CO_2/39.8%N_2 and T2: 0.2%CO/99.8%CO_2. The masterpacks were stored for 7, 14, 21 and 28 days at 1^{o}C. Four trays of each muscle were periodically evaluated for each treatment and removed randomly from two masterpacks under the same anoxic conditions to evaluate the treatment and muscle interaction analysis of gas composition, pH, visual and instrumental colour, brown discolouration (%) and overall appearance. Steaks from PM of low colour stability in both treatments T_1 and T_2 were similar in C* (Chroma) to beef meat at the beginning of the experiment. While T_1 was better ($P<0.05$) than the initial samples for steaks from GM, LD and ground beef from TB, it was similar to T_2 for steaks from GM and ground beef from TB. It was demonstrated that the carboxymyoglobin formed in the beef meat for T1 and T2 was more stable.The colour evaluation of T_1 was similar than initial values for steaks from GM and LD.

Introduction

The intermuscular variability is the most important single factor in meat colour stability. The different muscle tissues may have different capabilities of reducing metamyoglobin. According to O'Keeffe & Hood (1982), the susceptibility in relation to the formation of MetMb in the muscle is given by: *Bicepis femoris*> *Semimembranosus*> = *Semitendinosus* > *longissimus dorsi* = *Semitendinosus* (round stake) > *Gluteus medius*> *Psoas major* (tenderloin), and the latter being the muscle most susceptible to pigment oxidation. Therefore, the objective of this research was to evaluate if the distribution packages under high CO_2 concentrations associated to 0.2% CO are able to extend the colour stability of several beef cuts for 28 days at 1±1° C. *Gluteus medius* (GM), *Longissimus dorsi* (LD), *Triceps brachii* (TB) and *Psoas major* (PM) muscles were chosen for their economic interest for presenting intrinsic differences in colour stability between them.

Materials and methods

Preparation of samples and atmospheres: Muscles with normal pH (<5.8) were boned 72h after conventional slaughter and half carcasses (n = 12) removed from young Nelore raised on pasture.

Portions of approximately 300g of meat were packed in shallow expanded polystyrene trays. The trays were surrounded by PVC film of high permeability to oxygen. A set of four trays of the same cut were randomly placed in co-extruded bags of high impermeability to oxygen, commercially known as masterpack (polyethylene/PA/EVOH/PA/polyethylene). Before thermo sealing, ten bags of each product were evacuated and filled with about 2L of the following gas mixtures: (1) 0.2%CO/60% CO_2/39.8% N_2 or (2) 0.2%CO/99.8%CO_2. Five oxygen-absorbing sachets were placed in each bag. The distribution packages containing the products in modified atmosphere conditions were stored at 1.0° C ± 0.5° C for 28 days.

Gas Composition: CO_2 and O_2 concentrations in the free space of bags were evaluated during processing and immediately after each storage period before they were opened for removal of trays. The mean values were expressed as percentages of CO_2 and O_2 (v / v).

Sensory Analysis: The sensory attributtes were evaluated using a scale suggested by AMSA (1991). The meat colour was evaluated through a 9 cm non-structured scale based on extremes with descritive terms (Table 1). For discolouration, a mixed scale of five points was used (Table 1). The median point of each scale was considered as the product aceptability limit in relation to the attribute asessed, that is, after achieving this score, the product was no longer attractive, having lost its commercial value.

Instrumental colour: The colour measurements were performed on the meat surface using a spectrophotometer (MiniScan®XE Plus.). The coordinates CIE L * a * b *, the colour saturation index and hue angle of samples were obtained. The percentage of metamyoglobin on the meat surface was estimated by the simplified reflectance method (R630nm: R580nm) through spectral curves (AMSA 1991).

Statistical analysis: The experimental design was completely randomized with 8 x 4 x 2 factorial arrangement: two trays per treatment (T_1: 39.8 %N_2 / 60%CO_2/0.2%CO; T_2: 99.8 %CO_2/0.2%CO), four products (GM, LD, PM and ground beef from TB) and two replications of the entire experiment. The treatment means were calculated through the analysis of variance (ANOVA) using the Statistica^{TM} software.

Results and discussion

Gas Composition: Despite the use of oxygen absorbers, the residual concentration of oxygen was measurable during 28 days of storage at 1^{o}C (T2 = 2.8%). The oxygen concentration in T_2 was statistically superior to T_1 = 1.04% ($P < 0.05$) since the sealing of packaging (t = 0 day). The storage atmosphere was reduced from 60% to approximately 40% of CO_2 in T_1 and from 99.8 for about 60% of CO_2 for T_2 until the 21st day of storage.

Sensory Analysis: The initial visual colour of steaks from GM and LD was relatively higher than steaks from PM and ground beef from TB, which showed a reduced red colour intensity (C *) (Table 1).

In general, colour and visual appearance of samples under 0.2% CO/60% CO_2 was higher ($p<0.05$) than samples under 0.2% CO/99.8% CO_2, probably due to the higher discolouration percentage found in these samples.

The increase on the CO_2 concentration from 60 to 99.8% was even more harmful on colour and for the overall appearance of steaks from GM and LD than for steaks from PM and ground beef from TB. These differences, $P<0.05$, had little practical importance because, in both treatments, all products had predominantly red colour (score> 4.5), acceptable appearance (score> 3) and instrumental colour (L *, C * , h *) similar to the fresh meat.

Steaks from GM and LD stored under 0.2% CO/60% CO_2 showed homogeneous colour across their surface (0% of discolouration) and overall appearance similar to that of fresh meat, while samples stored under 0.2% CO/99.8% CO_2 showed small fractions of metamyoglobin (1-10%), which, however, was not sufficient to make their appearance unpleasant (scores <3).

Packaging under 0.2% CO/60% CO_2 increased the colour sensory scores of steaks from GM and ground beef from TB ($p<0.05$), while the visual colour of steaks from LD remained similar to fresh meat. The pronounced increase of red colour intensity (C *) positively influenced the appearance of steaks from GM, which in this atmosphere was generally higher ($P < 0.05$) than the fresh meat. These results agree with data obtained by Hunt et al (2004), who suggested that the application of CO is more beneficial for cuts with less colour stability such as GM, than for cuts with high stability such as the LD.

Analysis of the objective colour: Generally, the instrumental colour values confirmed the changes in vision colour due to treatment and time of storage under MA. In the CIEL*a*b* system, the main colour change observed in meat packed with 0.2% CO was the increase on the value of C*, which was significantly higher than or similar to fresh meat in all products evaluated (Table 1).

In an initial fresh meat assessment, only steaks from LD showed saturation indeces considered typical of fresh meat, in other words, higher than 20 (Table 1). Steaks from GM and PM and ground beef from TB had colour saturation lower than 18 before packing under MA, which is characteristic of meat with dark red colour. Treatment (T1) was significant for steaks from GM and LD ($P<0.05$) with increase on the red colour saturation (C*) followed by concomitant reduction on h*, while this treatment showed the same capacity as increase of C * and reduction of h * as for T2 for steaks from PM and ground beef from TB. The increased colour saturation along the storage period was more pronounced in cuts that presented increased colour stability such as GM and LD, which continuously increased the C * values, reaching maximum values around 21 - 25, after 28 days under MA, regardless of treatment (data not included).

Conclusions

The packaging of meat under 39.8%N_2/60%CO_2/0.2%CO seems to be the best technique for maintaining colour stability of *Gluteus medius*, *Longissimus dorsi* and *Psoas major* steaks and ground beef for 28 days at 1^{o}C, even in residual oxygen concentration considered excessive for anoxic packaging systems (> 0.1). After 28 days of storage under MA, rump, striploin and tenderloin steaks and ground beef showed acceptable appearance and visual colour similar to or above fresh meat.

Table 1. Averages for instrumental and sensory colour (muscle x treatment interaction) of products packed under modified atmosphere for 28 days at 1°C

	Treatment[1]	Beef products									SE[2]
		GM		LD		ground beef		PM			
L*	initial	41,85	aw	38,72	aw	47,55	bw	40,87	aw		0,25-0,21
	T1	38,18	ax	39,63	aw	43,11	bx	40,49	abw		
	T2	38,54	awx	40,68	acw	45,00	bwx	41,75	cw		
Chroma[3]	initial	17,89	aw	21,14	aw	16,25	aw	17,55	aw		0,21-0,24
	T1	25,10	ax	25,28	ax	20,63	bx	17,55	cw		
	T2	21,19	aw	23,77	awx	18,96	bwx	16,43	bw		
Hue[4]	initial	35,23	aw	34,72	aw	38,37	aw	38,20	aw		0,13-0,56
	T1	36,79	aw	36,44	aw	32,30	aw	31,14	aw		
	T2	40,30	aw	37,15	aw	32,81	aw	34,69	aw		
Visual colour[5]	initial	9,00	aw	8,67	aw	7,59	bw	6,85	bw		0,04-0,08
	T1	8,50	aw	8,67	aw	6,60	bx	5,93	cx		
	T2	6,02	ax	7,30	bx	6,67	cx	5,60	dx		
Discolouration (%)[6]	inicial	4,94	aw	4,94	aw	4,81	aw	4,81	aw		0,02-0,02
	T1	4,95	aw	4,88	aw	4,23	bx	3,86	cx		
	T2	4,31	ax	4,57	ax	4,16	ax	3,42	by		
Overall appearence	initial	4,50	aw	4,50	aw	4,19	aw	4,25	aw		0,04-0,03
	T1	4,44	aw	4,10	aw	3,58	cx	2,92	dx		
	T2	3,20	ax	3,18	ax	3,53	bx	2,58	cy		

[1] T_1 = 0.2% CO + 60% CO_2 + 39.8% N_2, T2 = 0.2% CO + 99.8% CO_2, [2] standard error, [3] Chroma = $(a^2 + b^2)^{1/2}$, [4] Hue angle = (b*/a *) tg^{-1}; [5] visual colour = 0cm = grayish brown; 4.5 cm = brownish red; 9cm = red typical of fresh meat; [6] Brown stain (%) = 5 = none (0%) 4 = light (1-10%), 3 = small (11-20%), 2 = moderate (21-60%); 1 = intense (61-100%); [7] Overall appearance: 5=very pleasant; 4=slightly pleasant; 3=little pleasant, 2=moderately unpleasant and 1=extremely unpleasant.
a-d Averages in the same row with different letters are statistically different (P <0.05).
w-z Averages in the same column with different letters are statistically different (P <0.05).

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