SHELF-LIFE EXTENSION AND COLOUR STABILIZATION OF BEEF PACKAGED IN A LOW O_2 ATMOSPHERE CONTAINING CO: 1.- LOIN STEAKS.

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INTRODUCTION

Modified atmosphere packaging (MAP) of fresh meat normally uses mixtures of oxygen (O_2), carbon dioxide (CO_2) and eventually nitrogen (N_2); each gas plays a specific role in order to extend shelf life and to maintain the good appearance of the package (Young et al., 1988). Spoilage of fresh meat has been shown to be delayed by the use of atmospheres with high concentrations of CO_2 (Huffman, 1974; Silliker et al., 1977). Nevertheless, its use at this concentration in red meat accelerates its discoloration (Ledward et al., 1971; Silliker et al., 1977). However, this dicoloration could be counteracted by the incorporation of 1% CO. Formed carboxymyoglobin (MbCO) is more stable than oxymyoglobin (MbO_2) and gives an atractive cherry-red colour to meat; it has been therefore suggested as a complementary gas for meat packaging (Gee & Brown, 1978, Parry, 1993).

The aim of this research was to investigate a new atmosphere for fresh beef steaks packaging combining low concentration of O_2 (highly interesting for industry because mixtures with more than 24% of O_2 have a risk to explode spontaneously), intermediate concentration of CO_2, with the known benefits in terms of bacterial growth inhibition, and very low concentration of CO (1%), which improves colour stability.

MATERIALS AND METHODS

Samples. Beef steaks (1.5 cm thick) were cut from *Longissimus lumborum* removed from the carcass 48 h post-mortem.

Packaging. Beef steaks were individually placed on polyestyrene trays of 15.5 x 21.5 cm and sealed (after flushing with the selected gas mixtures) with a laminated pouch of polyethylene and polyamide (water vapour permeability of 5-7 g/m^2/24 h at 23°C and oxygen permeability of 40-50 cc/m^2/24 h at 23°C) and stored at 1 ± 1°C. Gas mixtures consisted of 70% O_2 + 20% CO_2 + 10% N_2 (v/v) (control modified atmosphere; CMA), 70% O_2 + 20% CO_2 + 9% N_2 + 1% CO (high-oxygen, carbon monoxide; HO-CO) and 24% O_2 + 50% CO_2 + 25% N_2 + 1% CO (low-oxygen, carbon monoxide; LO-CO).

Microbiological analyses. Counts of aerobic psychrotrophic flora were determined in Plate Count Agar (Merck) incubated at 10°C for 7 days.

Instrumental colour measurement. Objective measurement of colour (L*, a*, b*) was performed at the surface of meat samples using a Minolta Chroma Meter CR-200 30 min after package opening. Psychometric parameters Chroma (C*) and Hue-angle (h) were calculated by the following formulas: $C^* = (a^{*2} + b^{*2})^{1/2}$, $h = \tan^{-1}(b^*/a^*)$. MetMb percentage was estimated also spectrophotometrically by measuring the reflectance at 525 and 572 nm according to Stewart *et al.* (1965).

Sensory analysis. Meat samples were evaluated by a trained panel of six members. The parameters studied were: 'External Humidity', 'Red Colour', 'Brown Colour', 'Odour Intensity' and 'Odour Quality'. Parameters were scored using a 9-point scale, 9 denoted extremely high and 1 denoted extremely low.

RESULTS AND DISCUSSION

Microbiological analyses. As it is shown in Fig. 1, the mere presence of 1 % CO into the packaging atmosphere had no effect on microbial growth, in agreement with Gee and Brown (1978). Samples packaged in control atmosphere (CMA: 70% O_2 + 20% CO_2 + 10% N_2) and HO-CO atmosphere (70% O_2 + 20% CO_2 + 9% N_2 + 1% CO) did not differed significantly. In contrast, LO-CO atmosphere (24% O_2 + 50% CO_2 + 25% N_2 + 1% CO) caused a reduction in psychrotrophic population (lower than 10^7 CFU/cm^2 at 29 d storage). A likely explanation of these results could be the higher concentration of CO_2 of this atmosphere (50 %). There is a controversy on the most adequate CO_2 concentration for obtaining maximal microbial inhibition; several authors (Brody, 1989) recommended 40-60%, while Seideman and Durland (1984) reported that 20-30% is enough for such purpose. In any case, our results reinforced the view that 20 % CO_2 is not enough for highest microbial inhibition, at least under the conditions of our experiment.

Instrumental colour measurement. CO stabilised red colour throughout storage (29 d) as it is clearly shown in Fig. 2; a* values did not differ significantly for samples packaged in an atmosphere with CO. In contrast, a* values decreased about 5 points along storage in control samples (CMA). These results confirmed the interest of atmospheres with CO in order to maintain for longer periods the bright colour of red meat, as previously reported El-Badawi et al. in 1964, Besser and Kramer in 1972, Clark et al. in 1976 and Gee and Brown in 1978.

Stability of Chroma (C*) and Hue-angle values in samples packaged with CO atmospheres revealed the efficacy of CO in maintaining an attractive colour for longer periods, while control atmosphere was not able to keep colour steady. Differences were more evident after 15 d of storage, as it is shown in Fig. 3.

MetMb. percentage evolution shown in Fig. 3 revealed a marked difference between control and samples packaged with CO. MetMb percentage after 29 d storage was 56.8% for samples packaged in CMA, while values for samples in atmospheres containing CO were clearly lower, about 15 %. It was noticeable that MetMb values were similar for both HO-CO and LO-CO atmospheres until 21 d storage.These results were in agreement with Gee and Brown (1978) and Lanier *et al.*, (1978).

Sensory analyses. Table 1 shows the results obtained for sensory parameters. External humidity was similar in all cases, and it was not modified during storage. Panel members appreciated a difference in "red colour" as earlier as 2 d of storage between samples packaged in CMA and CO-containing atmospheres. Samples packaged in LO-CO atmosphere were the best qualified in terms of bright red colour intensity. Matamoros and Rama (1973) reported very similar results on meat colour. 'Brown colour' was also evaluated by the sensory panel, and the results confirmed those obtained by instrumental analysis. This undesirable colour in control samples appeared at about 16 d storage, while it did not occur in samples packaged in atmospheres containing CO. Samples packaged in CMA had higher odour intensity, and their values increased during storage, as is shown in Table 1. Panel members found less intense odour in samples packaged in atmospheres containing CO; furthermore, odour quality was higher in these samples. LO-CO atmosphere was best in maintaining odour quality

CONCLUSION

An atmosphere containing 24% O_2, 50% CO_2, 24% N_2 and 1% CO improved meat packaging in terms of shelf-life extension and colour stability. An additional benefit of this gas mixture is that it does not present the risk of spontaneous explosion; this represents an improvement of security in manufacture, storage, transport and use of gas atmospheres.

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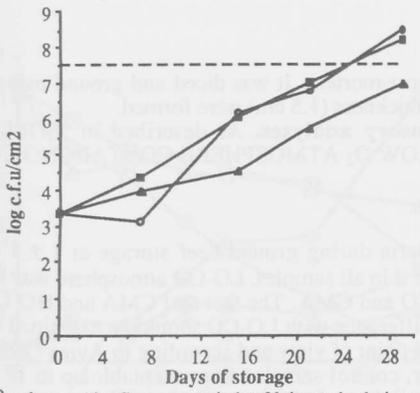

Fig. 1.- Psychrotrophics flora counts in beef loin steaks during storage at 1 ± 1°C. ○ CMA (70% O2+20%CO2+10%N2); ■ HO-CO (70% O2+20% CO2+10% N2 +1% CO); ▲ LO-CO (24% O2+50% CO2+25% N2+1% CO).

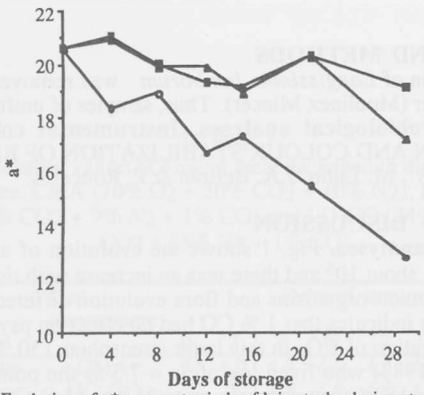

Fig. 2.- Evolution of a* parameter in beef loin steaks during storage at 1 ± 1°C. ○ CMA (70% O2+20%CO2+9%N2); ■ HO-CO (70% O2+20% CO2+9% N2 +1% CO); ▲ LO-CO (24% O2+50% CO2+25% N2+1% CO).

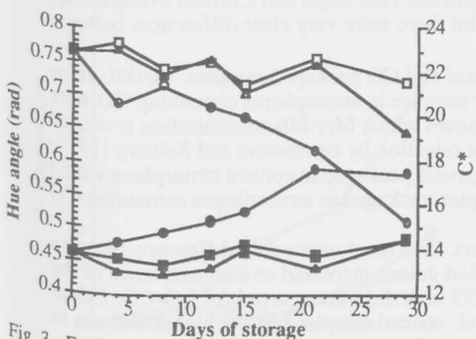

Fig. 3.- Evolution of Hue angle (closed symbols) and C* (open symbols) parameters in beef loin steaks during storage at 1 ± 1°C. Symbols as in Fig. 1.

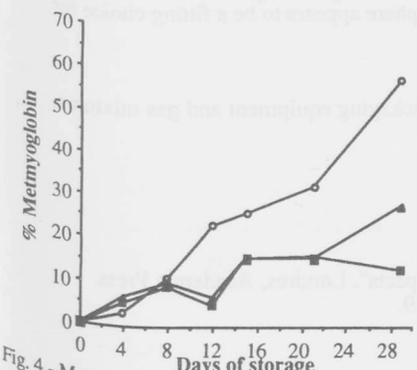

Fig. 4.- Metmyoglobin percentage in beef loin steaks during storage at 1 ± 1°C. ○ CMA (70% O2+20%CO2+10%N2); ■ HO-CO (70% O2+20% CO2+9% N2+1% CO); ▲ LO-CO (24% O2+50% CO2+25% N2+1% CO).

TABLE 1

Mean sensory values of meat packaged in different gas atmospheres. CMA (70% O_2 + 20% CO_2 + 10% N_2); HO-CO (70% O_2 + 20% CO_2 + 9% N_2 + 1% CO) and LO-CO (24% O_2 + 50% CO_2 + 25% N_2 + 1% CO).

Parameter	Gas atmosphere	Days of storage							
		0	2	4	8	12	15	21	29
Ext. Humidity	CMA	5	4,9	4,7	4,7	4,7	4,7	4,7	4,7
	HO-CO	5	5	4,7	4,7	4,7	4,7	4,7	4,7
	LO-CO	5	5	4,7	4,7	4,7	4,7	4,7	4,7
Red Colour	CMA	6,3	6,8	6,9	7	7	7	7	7
	HO-CO	6,3	8,5	8,5	8,5	8,5	8,5	8,5	8,5
	LO-CO	6,3	8,5	8,8	8,8	8,8	8,8	8,8	8,8
Brown Colour	CMA	1	1	1	1	1	1	3,2	6,1
	HO-CO	1	1	1	1	1	1	1	1
	LO-CO	1	1	1	1	1	1	1	1
Odour intensity	CMA	2	ND	2,5	3	5,2	5,4	6,9	7,2
	HO-CO	2	ND	1,6	1,6	3	3,5	4	4,7
	LO-CO	2	ND	1,2	2,2	3,4	3,5	4,1	4,1
Odour quality	CMA	7	ND	7	7	6,1	6	4	3,5
	HO-CO	7	ND	7	7	6,3	6,3	5,5	5
	LO-CO	7	ND	7	7	7	7	6,4	6,1

ND.- Not Determined.