Extending the shelf life of fresh beefsteaks packaged in modified atmosphere by UV-free lighting.

Djamel Djenane, Armida Sánchez, José Antonio Beltrán and Pedro Roncalés

Dept. of Animal Production and Food Science. Laboratory of Food Technology. Faculty of Veterinary Science. University of Zaragoza. C/ Miguel Servet, 177. 50013. Zaragoza, Spain.

Background and objectives: The type of lighting influences the display life of fresh red meat packaged in modified atmosphere. In retail display of fresh meat, consumers judge the quality of meat by means of the colour, and prefer the red oxymyoglobin (MbO_2) colour that brown metmyoglobin (MetMb) colour. Light plays a critical role in pigment photooxidation since it catalyses MetMb accumulation (Renerre *et al.*, 1993). Several authors have studied the effects of light for discoloration of fresh meat, although there are conflicting reports. Bertelsen *et al.* (1987) demonstrated in photochemical model experiments that MbO_2 in aqueous solution, at 0°C, was oxidised 50 times quicker by lighting at 334 nm, and 10 times at 366 nm, than at 546 nm. UV light is much more effective in inducing discoloration than visible light; even small radiation should not be neglected (Bertelsen *et al.*, 1986). Low wavelength visible light also intensified the initial oxidation of red MbO_2 to brown MetMb (Satterlee *et al.*, 1974; Setser *et al.* 1973). According to Renerre (1990), no particular wavelength seemed to enhance formation of MetMb in the visible spectrum; in contrast, UV light was harmful to fresh meat colour only after a short radiation. Besides this, it must be taken into account that most plastic materials used for packaging transmit light above 300 nm. The objective of our work has to investigate the effect of lighting on retail life of beef packaged in modified atmosphere. The absence of UV radiation, by means of either a polycarbonate filter or an UV-free colour balanced lamp, was compared to standard illumination and darkness.

MATERIALS & METHODS

Samples: Muscle Longissimus dorsi was removed from beef carcasses. Steaks (1,5 cm thick) were cut and were individually placed on polystyrene trays and sealed after flushing with a gas mixture consisting of 70% O_2 + 20% CO_2 + 10% N_2, in a laminated pouch of polyethylene and polyamide (PE/PA). **Display conditions:** Forty packs were stored in a display cabinet simulating retail conditions in supermarket, divided into four sections by vertical black screens. One section was illuminated by a standard supermarket fluorescent (Mazdafluor, Superaviva, TF/36W). The second section was illuminated by the same lamp with an UV filter sheet of polycarbonate. The third was illuminated by a low-UV, colour balanced lamp (Promolux). The fourth section remained in darkness. All samples were exposed to light continuously at 1000 lux at the surface. Lamp emission spectra are given in Fig. 1. Light transmission (%) characteristics of the packaging material and the UV-barrier were determined using a spectrophotometer (Unicam UV-Visible 500), from 180 to 700 nm. The PE/PA laminate used for packaging allowed transmission of about 80% of the visible light and 60-70% of the UV light from 330 nm to 380 nm; at 275 nm the transmission was 0%. The UV barrier (polycarbonate) allowed transmission of about 80% at 440 to 700 nm and 0 % below 400 nm. **Colour and metmyoglobin analysis**: The surface concentration (%) of MetMb was measured using a reflectance spectrophotometer (Minolta spectrophotometer CM-2002), according to Stewart et al (1965). Objective measurement of colour (CIE L*, a*, b*) was also performed at the surface of meat with the same spectrophotometer. **Lipid oxidation:** Oxidative rancidity was measured using the reaction of malonaldehyde with thiobarbituric acid, as described by Witte *et al.* (1970). **Microbial analysis**: Total bacterial count was determined by swabbing an area of 10 cm^2 of the meat surface. Using conventional dilution procedures in 0,1% peptone water, aerobic psychrotrophic flora was grown in plate count agar (Merck; Darmstadt) and incubated at 10°C for 7 days. Counts were expressed as colony forming units (cfu/cm^2). **Sensory analysis:** Odour was examined by six experienced evaluators, and scored using the following scale: 1 = Excellent, 2 = Good, 3 = Acceptable, 4 = Hardly acceptable, and 5 = Non acceptable.

RESULTS & DISCUSSION

Colour measurement: Values of a* (Fig. 2) differed significantly between samples displayed with conventional fluorescent light and all other display conditions. Final a* values for the former were about 4, while those of other display conditions were about 10. Our results were in agreement with previous reports. Zhu *et al.* (1998) have shown that samples stored in dark had higher values of a* than those displayed with light. Most important is the fact that samples displayed in the darkness showed no differences with those displayed under lighting free of UV radiation (polycarbonate filter and Promolux); this demonstrates that visible light (above 400 nm) allows maintenance of fresh meat red colour. **Metmyoglobin formation:** The accumulation of metmyoglobin is shown in Fig. 3. Beef steaks displayed under conventional light had more formation of metmyoglobin in the surface than other light conditions ($P<0,05$), which resulted in 66,77%, 63,64% and 58,20% more metmyoglobin formation than in samples stored in darkness after 17, 22, and 28 days of display, respectively. Only small ($P>0,05$) differences were observed between samples stored in darkness condition and those displayed under SF+UV and Promolux. **Evolution of TBARS:** The formation of TBARS during display of meat samples is shown in Fig.4. The rates of lipid oxidation appeared to be similar to the rates of discoloration and MetMb formation for samples displayed under different types of lighting. Samples stored in darkness showed greater protection for TBARS formation ($P<0,05$), which resulted in 43,95%, 52,02% and 43,69% less TBARS than in samples displayed under conventional light. Only small differences were observed between the latter and those displayed under other lighting conditions ($P>0,05$). According to Andersen et al. (1991), light is an important prooxidant in connection with lipid oxidation, in particular in the UV range. Our results demonstrated that the absence of UV radiation yielded a significant protection against photoinduced lipid oxidation. **Sensory analysis:** Table 1 shows the results of sensory scores for meat odour during display. Odour scores differed significantly from day 12 of display on between samples displayed under conventional light and all other samples. Odour of the samples displayed under conventional light was acceptable for only about 12 days, and corresponded at 1,76 TBARS values. Greene and Cumuze (1981) found that a TBARS range of 0,60 to 2,0 was required for detecting oxidised flavours. Samples displayed in darkness or without UV radiation had odour scores above 2 (good, in the scale) during the 28 days of display. **Microbial analysis:** Counts of total psychrotrophic flora (Fig. 5) showed that it increased more rapidly in samples under conventional lighting. In agreement with these results, Marriot *et al.* (1967) already claimed an increased microbial growth by effect of lighting. In fact, they supported that increased discoloration of meat under light had to be referred to enhanced

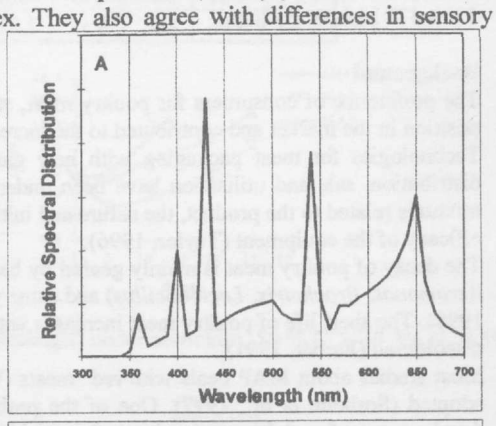
microbial growth. Our results showed that lighting free of UV radiation (polycarbonate filter and Promolux) gave rise to microbial counts very close to that of meat displayed in darkness. For the moment, we have no demonstrable explanation for this fact, although a possible effect of small temperature differences should not be overlooked. It is widely accepted that 7.5 log cfu/cm^2 is the approximate point at which off-odours appear. The samples displayed under the conventional lamp reached this point after about 20 days of display. Samples displayed under other types of lighting did not reach this point even at the end of the experiment (28 days). Microbial data are consistent with results of colour, odour, MetMb formation and TBA oxidation index. They also agree with differences in sensory characteristics of meat displayed under varying lighting conditions shown above.

CONCLUSION: The type of lighting markedly affected the retail life of packaged fresh beef. The absence of UV light in display lighting, by using either a polycarbonate filter or a Promolux lamp, significantly extended beefsteaks shelf life. Quality characteristics of steaks stored in darkness were very similar to those displayed under SF+UV- barrier or Promolux.

Acknowledgements This research work was supported in part by the Comisión Interministerial de Ciencia y Tecnologia (Grant No ALI 96-0587), Abelló Linde, S.A. (Spain), which provided the packaging equipment and gas mixtures, Smark S.A, which provided the Promolux lamps, and the Agencia Española de Cooperación Internacional (fellowships of authors Djenane and Sánchez).

REFERENCES

Andersen, H.J., & Skibsted, L.H. (1991). J. Food Sci. 56, 1182-1184.
Bertelsen, G.,& Boegh-Soerensen, L.(1986). Proc. I.I.R-Meeting.Bristol, 433-438.
Bertelsen, G., & Skibsted, L.H. (1987). Meat Sci. 19 , 243-251.
Greene, B.E., & Cumuze, T.H. (1981). J. Food Sci. 47, 52-54-58.
Marriot, N.F., Naumann, H.D., Stringer, W.C., & Hendrick, H.B. (1967). Food Technol. 21, 1518-1520
Renerre, M. (1990). Int. J. Food Sci. Technol. 25, 613-630.
Renerre, M., & Labadie, J. (1993). Proc. 39th Int. Congr. Meat Sci. Technol., Calgary, pp. 361-387.
Satterlee, L.D., & Hansmeyer, W. (1974). J. Food Sci. 39, 305-308
Setser, C.S., Harrison, D.L., Kropf, D.H., & Dayton, A.D. (1973). J. Food Sci. 38, 412-417.
Stewart, M.R., Zipser, M.W., & Watts, B.M. (1965). J. Food Sci. 30, 464-469.
Witte, V.C., Krause, G.F., & Bailey, M.E. (1970). J. Food Sci. 35, 582-585.
Zhu, L.G., & Brewer, M.S. (1998). J. Food Sci. 63, 763-767.



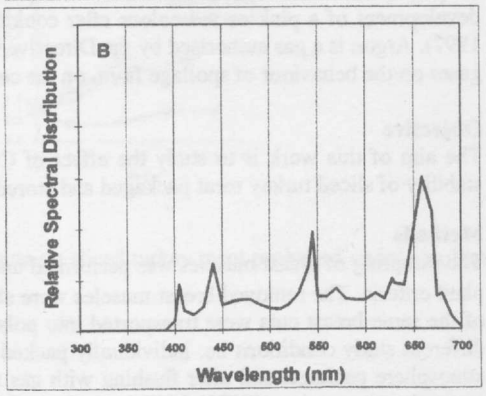


Fig. 1. Emission spectra of: A) Supermarket fluorescent (Mazdafluor Superaviva TF/36W); B) Low-UV, color balanced lamp (Promolux).

Table 1.- Sensory odour scores** in beef steaks packaged in modified atmosphere during retail display at 1±1°C.

	Type of lighting	Days of display					
		0	6	12	17	22	28
Odour quality	Darkness	1	1	1	1	1	2
	SF*	1	1	2	3	5	5
	SF+UV-barrier	1	1	1	2	2	2
	Promolux	1	1	1	2	2	2

*SF: Supermarket fluorescent. **1 = Excellent (not different from fresh meat), 2 = Good, but slightly poorer than fresh meat, 3 = Acceptable, 4 = Hardly acceptable as fresh meat, 5 = Non acceptable.

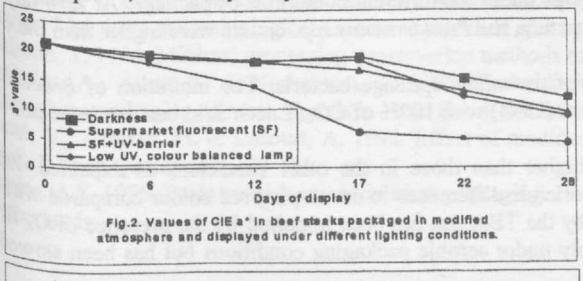


Fig.2. Values of CIE a* in beef steaks packaged in modified atmosphere and displayed under different lighting conditions.

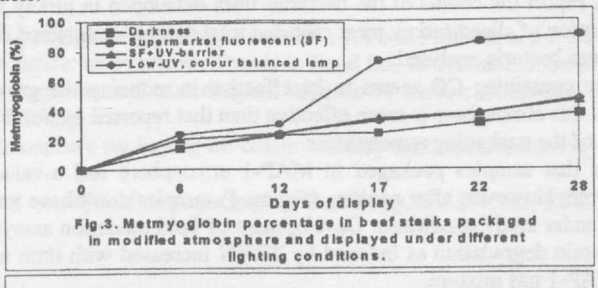


Fig.3. Metmyoglobin percentage in beef steaks packaged in modified atmosphere and displayed under different lighting conditions.

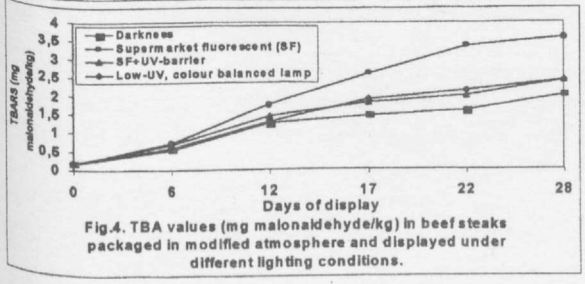


Fig.4. TBA values (mg malonaldehyde/kg) in beef steaks packaged in modified atmosphere and displayed under different lighting conditions.

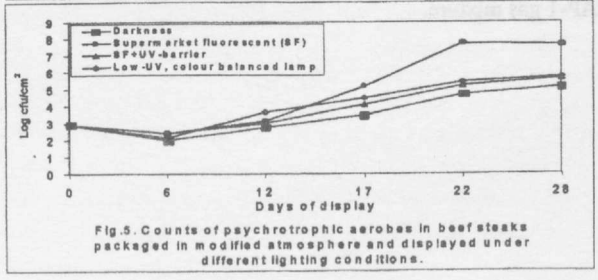


Fig.5. Counts of psychrotrophic aerobes in beef steaks packaged in modified atmosphere and displayed under different lighting conditions.