

EFFECT OF TEMPERATURE AND PACKAGING CONDITIONS ON PHYSICAL AND CHEMICAL STABILITY OF LAMB CHOPS

Bellés, M.¹, Alonso V.¹, Andreu, A.¹ Roncalés P.¹ and Beltrán J.A.¹

¹ Departamento de Producción Animal y Ciencia de los Alimentos, Facultad de Veterinaria, Universidad de Zaragoza, Zaragoza, España.

Abstract – The aim of this study was to investigate the effect of temperature and type of packaging on lamb quality throughout display. Legs from twenty lamb carcasses were removed and cut. Chops were vacuum skin and modified atmosphere packaged (40 % O₂/30% CO₂/30% Ar) and refrigerated at -0,5 and 4 °C in darkness. pH, instrumental colour and lipid oxidation were determined. Vacuum skin packaged meat avoided dramatically lipid oxidation both at -0,5 and 4 °C. Moreover, it showed a better maintenance of redness than modified atmosphere packaged lamb. Significant differences were found in TBARS values of modified atmosphere packaged lamb refrigerated at different temperature. Lamb stored at -0, 5 °C registered a faster development of rancidity than those was refrigerated at higher temperature. In conclusion, vacuum skin packaging resulted in a better chemical and physical stability than modified atmosphere packaging.

Key Words – refrigeration, rancidity, colour.

I. INTRODUCTION

Lamb is a high perishable product and its short shelf life is one of the factors that most concern meat industry [1]. Lamb colour is the main property valued by consumers at the time of purchase. Bright red colour is traditionally considered as a positive aspect since it is associated with freshness and superior quality product [2]. However, other characteristics such as odour, rancidity or tenderness could be significant in meat acceptance, which could decrease due to development of brown colour, formation of off odours and flavours, texture deterioration or/and superficial slime formation. Lipid oxidation has a significant role in meat spoilage, it affects colour, odour, flavour, texture and nutritional value [3]. Moreover, it is described a relationship between lipid and myoglobin oxidation according to which primary and secondary products of lipid oxidation enhances myoglobin oxidation, leading to meat discoloration [3, 4].

Nowadays, the trend is to sell packaged meat in refrigerated self-services display cases [6]. The temperature applied for meat preservation is commonly 4 °C, however low temperatures could extend lamb shelf life without quality decrease. Moreover, packaging has great advantages for dealers and markets because it is a mechanical barrier, reduces evaporative losses and has microbial and oxidative inhibitory effects if meat is surrounded with an adequate atmosphere. Modified atmosphere (MAP) and vacuum skin packaging (VSP) are the most used technologies to package meat for selling in self-services. Modified atmosphere packaged meat with high percentage of O₂ shows a bright red colour very attractive for consumers; however, oxygen in the pack enhances lipid oxidation. In contrast, vacuum skin packaging provides to lamb a less desirable colour at the time of purchase, but lipid oxidation could be reduced. Therefore, the main objective of this study was to assess the effect of temperature and type of packaging on the physical and chemical stability of lamb meat throughout the storage period.

II. MATERIALS AND METHODS

A. Animals and sampling

Twenty lamb carcasses were randomly chosen and chilled for 24 hours (-1,5 to 0, 5 °C). Later, the two legs of each carcass were removed and cut into chops, which were vacuum skin (Multivac R570 CD) and modified atmosphere (40% O₂/30% CO₂/30% Ar) packaged (ULMA-SMART-500). Samples were divided into four batches and stored in darkness at 4 ± 0,5 °C or -0,5 ± 0,5 °C for 28 days.

B. pH measurement

pH was measured in the muscle *Semimembranosus*

using a pH meter equipped with a glass electrode. Each value was the mean of four measurements that were carried out on each sample.

C. Instrumental measurement of colour

A Minolta CM-2002 (Osaka, Japan) spectrophotometer was used to measure colour at the surface of a 2-cm-thick chop after opening the trays and exposing them to air for 2 h. The parameters registered were L^* (lightness), a^* (redness) and b^* (yellowness). Each value was the mean of ten observations on the same chop.

D. Lipid oxidation

Lipid oxidation was measured by the 2-thiobarbituric acid (TBA) method [6]. TBA-reactive substances (TBARS) values were calculated from a standard curve of malondialdehyde and expressed as mg malondialdehyde per kg sample.

E. Statistical analysis

All data were statistically analyzed by the general linear model (GLM) procedure of IBM SPSS version 19 (IBM SPSS, 2010). The model included temperature, type of packaging and refrigeration storage duration as main effects and also their interaction. Tukey post hoc test was used to assess differences between mean values when $P \leq 0.05$.

III. RESULTS AND DISCUSSION

pH measurement

As can be seen in table 1, initial pH values were into the normal range (5,5-5,8) for lamb reported by Sobrinho et al. [7]. Changes in pH values throughout the storage time were slight in MAP; however, variations were dramatically in VSP. A different evolution was noted for vacuum packaged meat stored at different temperature. While pH values of samples stored at $-0,5\text{ }^{\circ}\text{C}$ increased, in which were stored at $4\text{ }^{\circ}\text{C}$ a rapid decrease was registered since 21th day of display. As a result, significant differences were found in their final values. This rapid pH decrease could be

due to lactic acid bacteria growth, which was significant higher in these preservation conditions.

Table 1. Means of lamb pH values.

Day	MAP $-0,5\text{ }^{\circ}\text{C}$	MAP $4\text{ }^{\circ}\text{C}$	Skin $-0,5\text{ }^{\circ}\text{C}$	Skin $4\text{ }^{\circ}\text{C}$
0	5,77 b/y	5,69 a/xy	5,58 a/x	5,63 b/x
7	5,72 ab/xy	5,70a/x	5,84 b/y	5,59 b/x
14	5,67 a/x	5,66 a/x	5,74 b/x	5,67 b/x
21	5,68 ab/xy	5,61 a/x	5,72 b/y	5,63 b/xy
28	5,69 ab/y	5,66 a/y	5,82 b/y	5,28 a/x

Different letters in the same row (x,y) indicate significant differences among packaging conditions ($P < 0,05$). Different letters in the same column (a, b) indicate significant differences among days of storage.

Instrumental colour

Table 2. Instrumental colour

	0	7	14	21	28
L^*	A 40,81 ^{a,x}	38,94 ^{a,x}	38,52 ^{a,x}	39,76 ^{a,x}	38,73 ^{a,x}
	B 38,75 ^{a,x}	39,54 ^{a,x}	41,11 ^{ab,xy}	44,47 ^{b,y}	44,32 ^{b,y}
	C 38,45 ^{a,x}	39,99 ^{a,x}	44,67 ^{c,y}	44,90 ^{b,y}	45,06 ^{b,y}
	D 40,15 ^{a,xy}	39,83 ^{a,x}	42,97 ^{bc,y}	41,28 ^{ab,xy}	43,28 ^{b,y}
a^*	A 11,83 ^{a,x}	14,23 ^{b,y}	15,78 ^{b,y}	15,54 ^{c,y}	15,29 ^{c,y}
	B 10,45 ^{a,x}	10,51 ^{a,x}	13,18 ^{b,y}	11,73 ^{b,xy}	10,64 ^{b,x}
	C 12,24 ^{a,y}	12,34 ^{ab,y}	8,29 ^{a,x}	8,50 ^{a,x}	5,39 ^{a,x}
	D 11,90 ^{a,z}	10,84 ^{a,yz}	7,94 ^{a,xy}	8,14 ^{a,x}	8,28 ^{a,xy}
b^*	A 13,75 ^{b,x}	13,63 ^{b,x}	15,31 ^{b,xy}	13,69 ^{a,x}	15,78 ^{a,y}
	B 10,99 ^{a,x}	10,77 ^{a,x}	13,28 ^{a,y}	14,40 ^{a,y}	14,13 ^{a,y}
	C 13,27 ^{b,x}	14,79 ^{b,x}	13,54 ^{a,x}	13,30 ^{a,x}	14,24 ^{a,x}
	D 13,25 ^{b,xy}	14,41 ^{b,y}	11,98 ^{a,x}	13,81 ^{a,xy}	15,80 ^{a,z}

A: VSP $-0,5\text{ }^{\circ}\text{C}$; B: VSP $4\text{ }^{\circ}\text{C}$; C: MAP $-0,5\text{ }^{\circ}\text{C}$; D: MAP $4\text{ }^{\circ}\text{C}$. Different letters in the same row (x,y) indicate significant differences among days of storage ($P < 0,05$). Different letters in the same column (a, b) indicate significant differences among packaging conditions.

Regarding the objective colour analyses, significant differences were found in the L^* , a^* and b^* values between treatments and throughout the storage period.

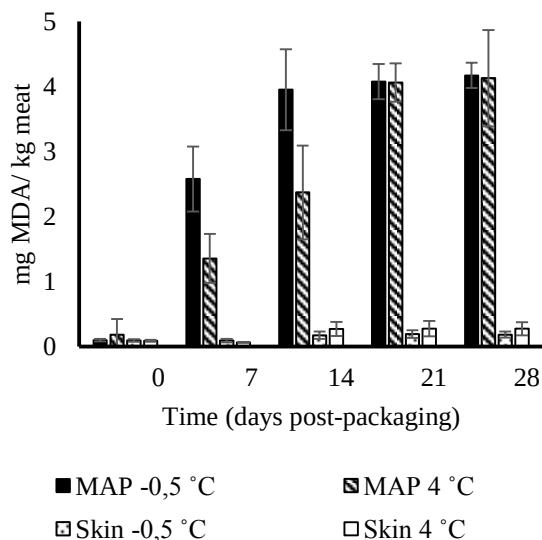
Vacuum skin packaged lamb refrigerated at $-0,5\text{ }^{\circ}\text{C}$ showed lower L^* values, and they remain invariable during the experimental time. In contrast, in the other treatments a continuous increase in L^* values was noted over time.

Readness (a^*) decreased significantly in modified atmosphere packaged lamb. Final values were 5,39 and 8,20 for meat refrigerated at $-0,5$ and 4 °C respectively. In contrast, vacuum skin packaged meat registered a better maintenance of redness. For lamb preserved at 4 °C final and initial values were similar, however, for those were stored at lower temperature an increase in a^* value was noted during display. Similar results were obtained by Berruga et al [2], who also registered a better stability in redness for vacuum than for modified atmosphere packaged lamb.

Lipid oxidation

Figure 1 shows the results for TBA reactive substances (TBARS) developing during display. None of the four preservation conditions could inhibit totally rancidity, whereas, enormous differences were registered between MAP and VSP. VSP was very effective in controlling lipid oxidation of lamb chops either at 4 °C or $-0,5$ °C, without differences between them. Several authors have already reported the effectiveness of vacuum packaging in controlling lipid oxidation of lamb [2, 8]. In contrast, a dramatic increase in rancidity was noted for modified atmosphere packaged lamb, which showed TBARS values well above 2 mg/kg at the 14th day of display. Modified atmosphere packaged lamb achieved 4 mg MDA/kg meat throughout the storage period. Similar values were reported by Berruga et al. [2] for modified atmosphere packaged (80% CO₂/20% O₂) lamb loin cuts stored at 2 °C and by Camo et al. [9] for modified atmosphere packaged lamb steaks (70% O₂/ 30% CO₂/ 10% N₂ and 50% O₂/ 30% CO₂/ 20% Ar) stored at 1 °C. Results agree with other authors [2, 10], who showed that the presence of oxygen favors lipid oxidation. However, in contrast to the expected results, refrigeration at $-0,5$ °C showed a faster development of rancidity than storing at higher temperature in modified atmosphere packaged lamb. Differences were significant at 7th and 14th days of display. After this time, there were no differences between them as maximum TBARS values were achieved.

Figure 1. TBARS in lamb chops during display.



IV. CONCLUSION

According to the results, we conclude that vacuum skin packaging was more efficient than modified atmosphere packaging in avoiding lipid oxidation. Moreover, it was also better in redness maintenance during the experimental time both in meat preserved at $-0,5$ and 4 °C.

On the other hand, further work is necessary to establish the reason for the unexpected differences obtained between rancidity of modified atmosphere packaged lamb refrigerated at different temperature.

ACKNOWLEDGEMENTS

The authors thank Franco y Navarro S.A. and Casa Ganaderos for providing the samples.

REFERENCES

Paper:

1. Wulf, D.M., Morgan, J.B., Sanders, S.K., Tatum, J.D., Smith, G.C. and Williams, S. (1995). Effects of dietary supplementation of vitamin E on storage and case life properties of lamb retail cuts. *Journal of Animal Science* 73: 339-405.
2. Berruga, M.I., Vergara, H. and Gallego, L. (2005). Influence of packaging conditions on microbial and lipid oxidation in lamb meat. *Small Ruminant Research* 57: 257-264.
3. Faustman, C., Sun, Q., Mancini, R. and Suman, P. (2010). Myoglobin and lipid oxidation

interactions: Mechanistic bases and control. *Meat Science* 86: 86-94.

4. Zakrys, P.A., Hogan, S.A., O'Sullivan, M.G., Allen, P. and Kerry, J.P. (2008). Effects of oxygen concentration on the sensory evaluation and quality indicators of beef muscle packed under modified atmosphere. *Meat Science* 79: 648-655.

5. Belcher, J.N. (2006). Industrial packaging developments for the global meat market. *Meat Science* 74: 143-148.

6. Pfalzgraf A., Frigg M. & Steinhart, H. (1995). Alpha- tocopherol contents and lipid oxidation in pork muscle and adipose tissue during storage. *Journal of Agricultural and Food Chemistry* 43: 1339-1342

7. Sobrinho, A.G.S., Purchas, R.W., Kadim, I.T. and Yamamoto, S.M. (2005). Meat quality in lambs of different genotypes and ages at slaughter. *Brazilian Journal of Animal Science*. 34: 1070-1078.

8. Kerry, J.P., O'Sullivan, M.G., Buckley, D.J., Lynch, P.B. and Morrissey, P.A. (2000). The effects of dietary α -tocopheryl acetate supplementation and modified atmosphere packaging (MAP) on the quality of lamb patties. *Meat Science* 56: 61-66.

9. Camo, J., Beltrán, J.A. and Roncalés, P. (2008). Extension of the display life of lamb with an antioxidant active packaging. *Meat Science* 80: 1086-1091.

10. Jeremiah, L.E. (2001). Packaging alternatives to deliver fresh meats using short- or long-term distribution. *Food Research International* 34: 749-772.