LIPID OXIDATION IN LIGHT LAMB: RELATIONSHIP BETWEEN INSTRUMENTAL MEASUREMENTS AND SENSORY ANALYSES

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Abstract – There are many factors which could influence meat quality. In this sense, lipid oxidation is a major concern. Oxidation is perceived at a sensory level as browning (visual) and rancidity (odour and taste) which finally leads to meat rejection. There has been described in several species a threshold for sensory perception of oxidation in relation to that assessed chemically. However, there is not a solid work on ovine species. In order to establish a threshold value of oxidation in light lamb, there has been performed an individual correlation analysis among panel sensory (visual, olfative and/or taste tests) and thiobarbituric reactive substances assays. From the data of 5 different studies, it could be suggested a range of 0.5 to 1.3 mg malonaldehyde/kg muscle as a possible threshold for sensory tests. Further investigation is needed to establish a more accurate level of detection and/or acceptance.

Key Words – Ovine, Rancidity, Threshold value

- INTRODUCTION

Oxidative processes in meat lead to the degradation of lipids and proteins which, in turn, contribute to the deterioration in flavour, texture, and colour of displayed meat products [1]. These processes are related to lipid oxidation [2] and microbial growth, being the main factors that determine food quality loss and shelf-life reduction. Currently, lipid oxidation is not considered to be a limiting factor for the shelf-life of aerobic-packed chill-storage meat since it occurs more slowly than discolouration or microbial growth [3]. However, some authors [4, 5] have observed the opposite. Hence, the importance of this factor becomes higher in light lamb intensively reared because of its fatty acid profile, highly prone to oxidation.

Several attempts have been made to determine the threshold in sensory perception of oxidation in relation to that assessed chemically [6] although threshold does not necessary indicate rejection. The interest of chemical assays rely on that they are objective, cheap and rapid, compared with organoleptic assessments [6]. However, this relationship is unclear. On one hand, there are many compounds that participate in rancid or off odour and/or flavour perception [7] but chemical assays usually detect one compound. On the other hand, when considered that TBARS (thiobarbituric acid-reactive substances) method measures products that do not contribute to flavour [8]. Nevertheless, there are references of a threshold acceptability value in beef [6] and pork [9]. However, there are scarce data in ovine species and the current references (i.e. [10], [11]) only suggest a possible value.

The aim of this work is to attempt a threshold value of oxidation detection in light lamb relating chemical and sensory data.

- MATERIALS AND METHODS

In all the studies, it was used the TBARS method described by Pfalgraf *et al.* [12] to determine lipid oxidation, expressed as mg malonaldehyde (MDA)/kg muscle. Meat was

obtained from lambs that were intensively reared and fed commercial concentrate after weaning up to 90 days old, and then slaughtered to get a hot carcass weight of 9-14 kg. Visual and odour tests were performed with leg chops and taste test was performed with *Longissimus lumborum* samples.

For the visual tests, samples were stored in a commercial expositor at 2-4 ºC with 12 hours of light exposure. Samples were evaluated (usually daily) for colour acceptability and purchase intention (Yes/No). Each sample was identified with a code, which was randomly changed every day to avoid sample recognition. An average of 15 expert panellists evaluated the samples using a structured 8-point hedonic scale from 1 (extremely dislike) to 8 (extremely like).

The odour tests were performed with the evaluations of six expert panellists after one session carry over to agree with the attributes and the scale to be used. Lamb, rancid and off odour intensities were evaluated using a structured 5-point scale from 1 (low) to 5 (high). Raw samples were kept at 2-4 °C and they were unpacked 15 minutes prior to analysis.

Taste panel involved nine trained panellists (ISO 8586-1, 1993) who evaluated meat samples based on a quantitative descriptive analysis. The sessions occurred in a controlled sensory analysis laboratory (ISO 8589, 1988) provided with individual booths. Samples were cooked at 200 °C on a pre-heated, double-grill hotplate, until the internal muscle temperature reached 70 °C, which was monitored by an internal thermocouple. Samples were kept at 50 °C until they were served (≤ 10 min after being cooked) in random order according to sample, replicate, and assessor. The parameters used were chosen in one session carry over to agree with the attributes and its description. The panel evaluated the samples on a semi-structured scale from low (0) to high (10) intensity.

To establish the relationship between the instrumental and sensory assays, there were calculated Pearson or Spearman correlations (when corresponding at the same time instrumental and sensory assays) with the SPSS Statistics 19.0 for Windows 7.

The design of the studies was as follows:

- Effect of diet supplementation (vitamin E and/or flavonoids; no supplemented) on lamb quality throughout display up to 10 days after packaging [13]. Lipid oxidation was analyzed and expert panellists performed a visual test.
- Effect of dietary supplementation (commercial antioxidant in test *vs.* no supplemented) on lamb quality. Lipid oxidation was analyzed and expert panellists performed an odour test throughout display up to 11 days after packaging.
- Effects of cooling temperature (0-2, 2-4, or 4-6 °C) and hot carcass weight (≤10.5 or ≥ 12.0 kg) on lamb quality [14]. Lipid oxidation was analyzed and sensory test involved a trained taste panel.
- Effect of freezing method (air blast, tunnel or nitrogen chamber) and frozen storage duration (from 1 to 6 months) on lamb quality [5, 15]. Lipid oxidation was analyzed and sensory test involved a trained taste panel.
- Effect of frozen storage duration (from 1 to 21 months) on lamb quality. Lipid oxidation was analyzed, a sensory test involved a trained taste panel and an expert panel performed a visual test.

- RESULTS AND DISCUSSION

Visual acceptability was significantly correlated with TBARS value, with decreased acceptability as oxidation was higher. Correlation values in Study 1 (Table 1) were higher at 4-

d display, where average oxidation was 0.375±0.20 mg MDA/kg muscle and average visual acceptability was 5.74±1.43, with a purchase intention of 83%.

Table 1 Lipid oxidation value and correlation (index and signification) with visual test[x]. Study 1

Visual acceptability	Correlation			
	0 days	4 days	7 days	10 days
TBARS[1]	ns	-0.62 (***)	-0.36 (**)	-0.38 (**)

[x] Visual test related with the correspondent TBARS day.
[1] TBARS: Thiobarbituric acid reactive substances. ns: no significant; **: p≤0.01; ***: p≤0.001.

For the Study 5 (Table 2), correlation values were higher at 3-d display, where average oxidation was 1.092±0.65 mg MDA/kg muscle and average visual acceptability was 4.90±1.22, with a purchase intention of 50%.

Considering the values of both studies, it could be established a range over 0.4 up to 1.0 mg MDA/ kg muscle to have a positive visual acceptability, which could be translated to lower oxidation (browning) detection. This range agrees with Camo *et al.* [10], who showed that TBARS value had to be greater than 1.0 to produce a change in red colour scores and higher than 3 to produce rejection.

Table 2 Lipid oxidation value and correlation (index and signification) with visual test[x]. Study 5

Visual acceptability	Correlation		
	0 days	3 days	6 days
TBARS[1]	-0.31 (*)	-0.51 (***)	-0.29 (*)

[x] Visual test related with the correspondent TBARS day.
[1] TBARS: Thiobarbituric acid reactive substances. *: p≤0.05; ***: p≤0.001.

Raw odour scores were not correlated with TBARS values at any display duration (Table 3). However, it was observed a decrease in lamb odour score and an increase in rancid and off odour intensity as TBARS value and ageing increased (data not shown), in agreement with Campo *et al.* [6] and Lanari *et al.* [9]. At 4d-display, rancid and off odours were scored above 1 point, and at 7d-display, both were scored above lamb odour intensity. These values corresponded to 1.356±0.61 and 2.654±0.86 mg MDA/kg muscle respectively, range which could be considered as a threshold in odour. It has been described a threshold above 1.5 mg MDA/kg muscle for off odour detection [9], which ranges up to 2.0 mg MDA/kg muscle on inexperienced evaluators, in agreement with the observed results, and also in accordance with Nieto *et al.* [16].

Table 3 Lipid oxidation value and correlation (signification) with odour test[x]. Study 2

Odour intensity/ TBARS	Correlation			
	0 d	4 d	7 d	11 d
Lamb odour	ns	ns	ns	ns
Rancid odour	ns	ns	ns	ns
Off odour	ns	ns	ns	ns

[x] Odour test performed with the correspondent TBARS day. ns: no significant.

On the sensory test (Tables 4 to 6), lipid oxidation was correlated with sensory variables. These variables or the significance value were different among studies, which may be due to differences in meat characteristics. In the Study 3 (Table 4), TBARS was correlated with lamb and off odour (usually described as rancid [17]), with increased intensity as greater TBARS. Average values were 0.134±0.01 mg MDA/kg muscle and a lamb and off intensities were 4.26± 0.66 and 1.98±1.07, respectively.

Table 4 Lipid oxidation value and correlation (index and signification) with sensory test. Study 3

	Odour intensity			Flavour intensity			
	L	F	Off	L	F	M	Acid

TBARS[1]	0,22 (t)	ns	0,28 (*)	ns	ns	ns	ns

[1] TBARS: Thiobarbituric acid reactive substances. L: lamb; F: fat; M: metallic. ns: no significant; t: p≤0.1; *: p≤ 0.05.

In the Study 4 (Table 5), TBARS was correlated with lamb flavour, with decreased intensity as greater TBARS. Average values were 0.140± 0.07 mg MDA/kg muscle, and a lamb flavour intensity of 5.66±0.38. Old meat intensity was 2.25±0.32, which could be confounded with rancid perception.

Table 5 Lipid oxidation value and correlation (index and signification) with sensory test. Study 4

	Odour intensity			Flavour intensity		
	L	F	S	L	F	O
TBARS[1]	ns	ns	ns	-0.19 (t)	ns	ns

[1] TBARS: Thiobarbituric acid reactive substances. L: lamb; F: fat; G: grass; S: sour; O: old meat. ns: no significant; t: p≤0.1.

In the Study 5 (Table 6), TBARS was correlated with lamb odour, with increased intensity as greater TBARS. Average values were 0.129± 0.05 mg MDA/kg muscle and a lamb odour intensity of 5.86±0.59, similar to Study 4. Old meat intensity was 3.31±0.96, which could be confounded with rancid perception.

Table 6 Lipid oxidation value and correlation (index and signification) with sensory test. Study 5

	Odour intensity			Flavour intensity			
	L	F	G	L	F	S	O
TBARS[1]	0,38 (*)	ns	ns	ns	ns	ns	ns

[1] TBARS: Thiobarbituric acid reactive substances. L: lamb; F: fat; G: grass; S: sour; O: old meat. ns: no significant; *: p≤0.05.

The low TBARS value (around 0.135 mg MDA/kg muscle) could be the cause for the lack of the rancid descriptor in the profiles. Besides, as lipid oxidation compounds interact with other volatile components [17] and the fact that rancid odour decrease related to other odours as concentrate feeding increases [7], all could minimize this threshold of perception and caused the low correlation observed with chemical data. Also, display or ageing comparison would be needed to get a more accurate threshold.

- CONCLUSION

From the data of five studies in light lamb quality it could be suggested a threshold detection range of 0.5 to 1.3 mg MDA/kg muscle for rancid detection at a sensory level. Further investigation is needed to establish a more accurate threshold.

REFERENCES

- Decker, E. A., Chan, W. K. M., Livisay, S. A., Butterfield, A. & Faustman, C. (1995). Interactions between carnosine and the different redox status of myoglobin. Journal of Food Science 60: 1201-1204.
- Buckley, D. J., Morrissey, P. A. & Gray, J. I. (1995). Influence of dietary Vitamin E on the oxidative stability and quality of pig meat. Journal of Animal Science 73: 3122-3130.
- Zhao, Y., Wells, J. H. & McMillin, K. W. (1994). Applications of dynamic modified atmosphere packaging systems for fresh red meats: A review. Journal of Muscle Foods 5: 299-328.
- Jakobsen, M., & Bertelsen, G. (2000). Colour stability and lipid oxidation of fresh beef. Development of a response surface model for predicting the effects of temperature, storage

time, and modified atmosphere composition. Meat Science 54: 49-57.
- Muela, E., Sañudo, C., Campo, M. M., Medel, I. & Beltrán, J. A. (2010). Effect of freezing method and frozen storage duration on instrumental quality of lamb throughout display. Meat Science 84: 662-669.
- Campo, M. M., Nute, G. R., Hughes, S. I., Enser, M., Wood, J. D. & Richardson, R. I. (2006). Flavour perception of oxidation in beef. Meat Science 72: 303-311.
- Resconi, V. C., Campo, M.M., Montossi, F., Ferreira, V., Sañudo, C. & Escudero, A. (2010). Relationship between odour-active compounds and flavour perception in meat from lambs fed different diets. Meat Science 85: 700-706.
- Tarladgis, B. G., Watts, B. M., Younathan, M. T. & Dugan, L. (1960). A distillation method for the quantitative determination of malonaldehyde in rancid foods. Journal of American Oil Chemist's Society 37: 44-48.
- Lanari, M. C., Schaefer, D. M. & Scheller, K. K. (1995). Dietary vitamin E supplementation and discoloration of pork bone and muscle following modified atmosphere packaging. Meat Science 41: 237-250.
- Camo, J., Beltrán, J. A. & Roncalés, P. (2008). Extension of the display life of lamb with an antioxidant active packaging. Meat Science 80: 1086-1091.
- Ripoll, G., Joy, M., Muñoz, F. & Albertí, P. (2011). Use of dietary vitamin E and selenium (Se) to increase the shelf life of modified atmosphere packaged light lamb meat. Meat Science 87: 88-93.
- Pfalzgraf, A. Frigg, M. & Steinhart, H. (1995). α tocopherol contents in lipid oxidation in pork muscle and adipose tissue. Journal of Agriculture and Food Chemistry 43: 1339-1342.
- Muela, E., Sañudo, C., Campo, M. M., Medel, I., Sebastián, M., Granizo, J. & Beltrán, J.A. (2009). Effect of diet supplementation on lamb meat quality. Book of abstracts of the 60th Annual Meeting of the European Association of Animal Production (EAAP), p.51.
- Muela, E., Sañudo, C., Campo, M. M., Medel, I. & Beltrán, J. A. (2010). Effects of cooling temperature and hot carcass weight on the quality of lamb. Meat Science 84: 101-107.
- Muela, E., Sañudo, C., Campo, M. M., Medel, I. & Beltrán, J. A. (2012). Effect of freezing method and frozen storage duration on lamb sensory quality. Meat Science 84: 209-215.
- Nieto, G., Díaz, P., Bañón, S. & Garrido, M. D. (2010). Dietary administration of ewe diets with a distillate from rosemary leaves (*Rosmarinus officinalis, L.*): Influence on lamb meat quality. Meat Science 84: 23-29.
- Gray, J. L. & Pearson, A. M. (1994). Lipid-derived off-flavours in meat formation and inhibition. In F. Shahidi (Ed.), Flavour of meat and meat products (pp. 116-143). London: Blackie Academic.