THE EFFECT OF DIETARY VITAMIN E SOURCE AND DOSE ON LAMB MEAT COLOUR STABILITY UNDER RETAIL CONDITIONS

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Abstract – The effect of natural (NE) and synthetic vitamin E supplementation (SE) on lamb meat packed under modified atmospheres (MAP) for 14 days was studied. Three hundred and sixty *Rasa Aragonesa* lambs were offered nine dietary treatments (0, NE125, NE250, NE500, NE1000, SE250, SE500, SE1000 and SE2000). Lambs had *ad libitum* access to the experimental compound feed and wheat straw, for 14 days (pre-slaughter). After slaughter (24h), twelve left *longissimus thoracis et lumborum* (LTL) muscles per treatment group were extracted, sliced and MAP packed. Lamb chops were accessed for colour (*a and *L**) and *m-protein* forms (MMb and DMb) at day 1, 7, 9, 12 and 14 of display under retail conditions. Increased supplementation of vitamin E led to a reduction in *L**, DMb degradation and consequently, MMb. Redness (a*) of the chops was improved by vitamin E supplementation. Both sources of vitamin E were effective in protecting meat colour over the 14 days of display. However, similar effects in colour preservation were obtained at lower dosages of natural vitamin E. In general, supplementation of lamb diets with vitamin E is an effective measure to delay colour deterioration of MAP lamb, under retail conditions for periods longer than 7 days.**

Key Words – lipid oxidation, colour, modified atmosphere

I. INTRODUCTION

Meat quality in lambs, as defined by its colour stability along shelf-life, is a major factor driving consumer preference [1]. Oxygen rich packaging technologies like modified atmospheres (MAP), are commonly used by retailers to maintain a bright-red colour of refrigerated meat [2]. However, high levels of O_2 in MAP (70% to 90%) are also associated with increased lipid oxidation, and therefore, a reduction in display time. To overcome that, a combined use of supra-nutritional levels of dietary vitamin E with MAP is recommended [3]. High levels of α-tocopherol in feed and consequently in meat, are associated with a decrease in lipid oxidation [4], increased colour stability [5] and consequently shelf-life [6].

The majority of vitamin E used both in human and animal nutrition is of synthetic origin (all-rac-α-tocopheryl acetate). However, only 1 of the 8 stereoisomers that compose the racemic mixture of synthetic vitamin E can be found in nature (RRR-α-tocopherol) [7]. In order to discriminate between vitamin E sources, an official bioavailability factor of 1.00 for all-rac-tocopheryl acetate (synthetic vitamin E) and 1.36 for RRR-α-tocopheryl acetate (natural vitamin E), was established [8]. However, recent studies [7; 9] have demonstrated that the relative bio-availability of different vitamin E sources maybe different from the 1.36 ratio currently in use. Moreover, this bio-availability equivalence may also vary depending on different meat quality targets/endpoints. The purpose of the present experiment was to investigate the effect of different dietary levels of Natural (NE) and Synthetic (SE) on meat colour of lamb meat, displayed under retail conditions for as long as 14 days.

II. MATERIALS AND METHODS

Three hundred and sixty *Rasa Aragonesa* lambs with an average body weight (BW) of 22.3 ± 0.25 kg, were penned following a randomized complete block design. Lambs were blocked by sex (equal number of male and females) and batch (2 in total). Within each of 4 blocks, pens were randomly assigned to one of nine treatments. Two sources of dietary α-tocopheryl acetate (natural and synthetic) at 4 supplementation levels were

added to the basal compound feed (CF): Control diet (no additional vitamin E); 125, 250, 500 and 1000 mg/kg CF of natural vitamin E (NE125, NE250, NE500 and NE1000, respectively); 250, 500, 1000 and 2000 mg/kg CF of synthetic vitamin E (SE250, SE500, SE1000 and SE 2000, respectively). Lambs were offered *ad libitum* access to the experimental compound feed and wheat straw, for 14 days before slaughter. Thereafter, lambs were slaughtered at a local slaughter house with a BW of 25.8 ± 0.71 kg.

After 24h *post-morten* at 4°C, the left *Longissimus thoracis et lumborum* (LTL) muscle from 3 lambs per pen was extracted. The muscles were sliced into 2 cm thick steaks and packed in polystyrene trays sealed with polyethylene and polyamide laminate film, using a packaging machine. A modified atmosphere (MA) of 70% O_2 + 30% CO_2 was applied to each tray, before displayed under retail conditions (4°C±1°C, with 14h fluorescent light) during 14 days of storage. Chemical and physical analyses were performed on day 1, 7, 9, 12 and 14 days after slaughter.

A Minolta reflectance spectrophotometer (CM-2002; Osaka, Japan) was used to measure surface colour of LTL chops. After opening the trays and exposing to air for 2h, values of *a**(redness) and *L**(lightness) were taken. Each value is the average of 10 consecutive observations on the same sample.

The relative contents of *dexosimyoglobin* (DMb) and *metmyoglobin* (MMb) were calculated according to Krywicki (1979) [10]. Due to limitations in the reflectance spectrophotometer that measures reflectance between 400-710nm at 10 nm intervals, the wavelengths 473, 525 and 572 nm were linearly interpolated. Each value is the average of 10 readings at different locations of the same slice at each time point.

All statistical analysis were carried out using the MIXED procedure of SAS (version 9.3, SAS Institute, Cary, NC, USA). The objective was to study the relationship of vitamin E source and dose (D) with the development of the color parameters during storage time (T). The model used was:

$$Y_{ij} = \mu + BLOCK + a_1T + a_2T^2 + b_1D + b_2D^2 + c_1TxD + d_1T^2xD + e_1TxD^2 + f_1T^2xD^2 + \varepsilon_{ij}$$

Where Y_{ij} are tested colour parameters $_i$ and vitamin E source and dose $_j$. μ is the general intercept; BLOCK is the fixed effect of block; a_1, a_2, b_1, b_2, c_1, d_1, e_1 and f_1 are the regression coefficients; and ε_{ij} the random residual error term. Non-significant variables ($P<0.05$) were removed stepwise until only significant variables remained.

III. RESULTS AND DISCUSSION

The relationships between vitamin E source and dose on the selected colour parameters and pigments are presented in Table 1.

Table 1. Significance values of the regression analysis using vitamin E source and dose as a predictor of colour development throughout MAP display period.

	T	T^2	D	D^2	T x D	T^2 x D	T x D^2	T^2 x D^2
*L**								
SE	**	**	ns	ns	ns	*	*	ns
NE			ns	ns	ns	*	ns	ns
*a**								
SE	**	**	ns	ns	ns	**	**	ns
NE			ns	ns	ns	**	**	ns
DMb								
SE	**	**	ns	ns	ns	**	ns	**
NE			ns	ns	ns	**	ns	**
MMb								
SE	*	*	ns	ns	t	**	t	*
NE			ns	ns	*	**	*	**

SE = synthetic vitamin E; NE= natural vitamin E.
ns = non-significant; * = $P<0.05$; ** = $P<0.01$.
T=linear effect of time; T^2=quadratic effect of time; D=linear effect of dose; D^2=quadratic effect of dose; T x D= interaction time and dose; T^2 x D= interaction time quadratic and linear dose; T x D^2= interaction linear time and quadratic dose; T^2 x D^2=interaction quadratic time and quadratic dose.

The changes in LTL chops colour (*L**and *a**) over 14 days of display under MAP are shown in Figure 1. Chops from all the supplemented groups had lower *L** (luminosity) values than the control lambs, independently from source. However, steaks from NE fed lambs had also lower levels of *L** than chops from SE. A previous lamb study [11], pointed that lower *L** values are related to lower superficial moisture and an increased water holding capacity of the meat.

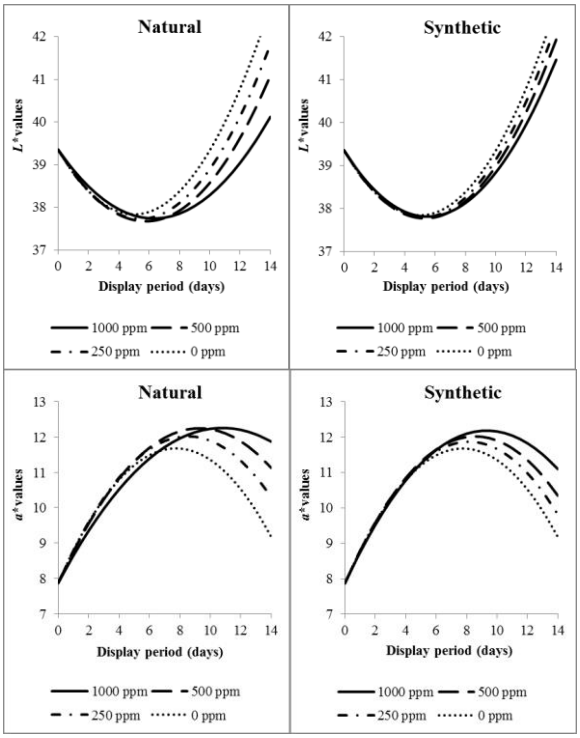

Figure 1. Evolution of *L** and *a** values for natural and synthetic vitamin E at different supplementation levels throughout MAP display period.

Vitamin E supplementation reduced the *a** (redness) loss compared with the control (Figure 1). The values in most of the supplemented groups (excluding SE250) were above 10 at the end of the display period, which indicates a bright-red colour of the chops [12]. Notwithstanding, NE was more effective in maintaining higher *a** values than SE, at similar doses.

The effect of dietary supplementation with Vitamin E and preservation time on *m-protein* forms are presented in Figure 2.

%DMb was affected by dietary supplementation. The control group had consistently lower DMb percentages than the supplemented groups, from day 10 onwards. Moreover, source had also an affect in %DMb as shown in figure 2, lower doses of NE yielded higher %DMb than SE. Previous authors [14], pointed that lower muscle depletion of dissolved oxygen as a result of lower lipid oxidation is the primary cause for higher %DMb. As demonstrated by Lopez-Bote *et al.* (2001) [15], vitamin E supplementation can effectively delay lipid oxidation in lamb meat and therefore affect %DMb degradation.

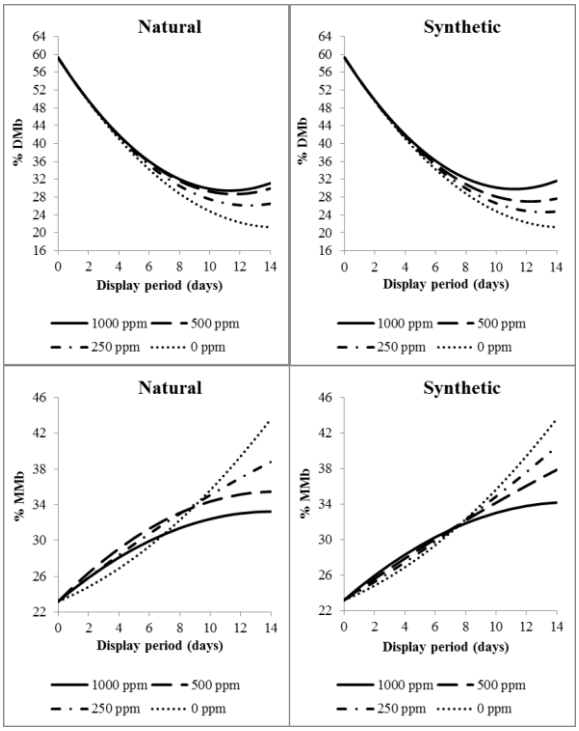

Figure 2. Evolution of DMb and MMb percentages for natural and synthetic vitamin E at different supplementation levels throughout MAP display period.

Results of %MMb formation were aligned with the previously described %DMb. It was found that NE delayed MMb development more effectively than SE, at similar dose. Control chops presented higher values than any other group from 10 days of display onwards; at day 14, MMb percentage was higher than 40%. In a beef study, 40% MMb values in meat were reported to cause significant consumer rejection [16].

IV. CONCLUSION

Increased supplementation levels of vitamin E (Natural and Synthetic) protected MAP lamb meat against discoloration (*a** and *L**) and *m-proteins* (%DMb and %MMb), during 14 days of display. Natural vitamin E, however was consistently more effective than SE at delaying meat degradation. Further investigation is warranted to determine the equivalence between sources of vitamin E in different meat colour parameters/endpoints.

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