Lamb meat colour stability as affected by dietary tannins

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ABSTRACT - Twenty-one male Comisana lambs were divided into three groups at 45 days of age and were individually penned for 60 days. Seven lambs were fed a concentrate-based diet (C), seven lambs received the same concentrate with the addiction of tannins from quebracho (*Schinopsis lorentzii*; T), whereas the remaining animals were fed exclusively fresh vetch (*Vicia sativa*; H). Colour descriptors (a^*, b^* and H^*) and metmyoglobin (MMb) percentages were measured on minced *semimembranosus* muscle over 14 days of refrigerated storage in a high oxygen atmosphere. Regardless of dietary treatment, meat redness decreased, while yellowness and hue angle increased ($P < 0.001$) over storage duration. However, higher a^* values, lower b^* values and lower H^* values were observed in meat from both H- and T-fed animals as compared to meat from C-fed lambs ($P = 0.012$; $P = 0.02$; $P = 0.003$, respectively). Metmyoglobin formation increased over time ($P < 0.001$), but H diet resulted in lower metmyoglobin percentages than C diet ($P = 0.007$). We conclude that the inclusion of tannins into the concentrate improved meat colour stability compared to a tannin-free concentrate. Moreover, the protective effect of tannins against meat discolouration was comparable to that obtained by feeding lambs fresh herbage.

Key words: Meat Colour, Herbage, Concentrate, Tannins.

Introduction - For red meats, colour is considered as one of the main meat quality parameters, being a sensory attribute influencing, more than others, consumers' purchase decisions (Liu *et al.*, 1995). Oxidative processes in meat are favoured by *post mortem* biochemical changes, with myoglobin oxidation leading to meat discoloration (Renerre *et al.*, 1996). Therefore, the possibility of extending meat shelf life by delaying oxidative deterioration represents an important objective.

Dietary strategies have been extensively tested as means of improving meat colour stability. Compared to a concentrate-based diet, feeding animals green herbage has been often reported to extend meat shelf life by providing natural antioxidants (Wood and Enser, 1997). Tannins extracted from quebracho (*Schinopsis lorentzii*), when added to a concentrate-based diet, have been shown to improve meat colour stability as compared to a tannin-free concentrate (Luciano *et al.*, 2009).

The aim of this research was to use dietary tannins to efficaciously extend lamb meat colour stability. To test this hypothesis we compared a diet comprising of a tannin-containing concentrate both with a conventional tannin-free concentrate – normally resulting in a short meat shelf life – and with a herbage-based diet – normally resulting in an improved meat oxidative stability.

Material and methods - Twenty-one male Comisana lambs were blocked, at 45 days of age, in groups of three on a descending bodyweight basis and, within block, were randomly assigned to one of

three dietary treatments. All the lambs were kept in individual pens for the duration of the trial. Over 60 days, seven animals (C) were fed a concentrate comprising, on an as fed basis, 551 g/kg of barley, 300 g/kg of alfalfa hay, 130 g/kg of soybean meal and 19 g/kg of mineral and vitamin premix. Seven lambs (T) received the same concentrate added with 8.9%, on a dry matter basis, of quebracho powder (a tannin-rich extract). The remaining seven animals (H) were fed fresh *Vicia sativa ad libitum* which was harvested daily. The amounts of feed provided to C and T groups were modulated weekly in order to allow the animals from the three experimental groups to grow at similar rates.

Immediately after slaughtering, *semimembranosus* (SM) muscle was excised from the left hind leg vacuum-packaged and frozen at -20°C. The muscles were minced and divided into three subsamples which were placed in individual gas impermeable polyamide/polyethylene bags and packaged in a high oxygen modified atmosphere (MAP; 80% O_2 : 20% CO_2). Meat was stored at 4°C in the dark and the analyses were performed after 2 hours of blooming (day 0) and after 7 and 14 days of storage. CIE colour coordinates (a^* and b^*) were measured using a Minolta CR300 colour meter. The D65 illuminant and 10° standard observer were used. Hue angle (H^*) was calculated as $\tan^{-1}$ (b*/a*) × (180/π). Simultaneously, haem pigments were extracted as described by Warriss (1979) and metmyoglobin (MMb) percentages were estimated following the method of Krzywicki (1982). The statistical software Minitab (14, 1995) was used to analyse the data with a GLM procedure with repeated measures. Diet (D; C, T and H) and time (T; days 0, 7 and 14) and their interaction (D×T) were considered as fixed effects, while individual lamb was included as random effect. Means were compared using the Tukey's test.

Results and conclusions - The inclusion of tannins into the concentrate resulted in a lower average daily gain (ADG) as compared to both C and H diets (84.2, 159.7 and 140.6 g, respectively; $P < 0.01$). However, lambs fed C, T and H had similar body weight at slaughter (30.3, 27.2 and 20.6 kg, respectively). Regardless of dietary treatment, meat redness (a^* values) decreased across the 14-days period of storage ($P < 0.001$; Table 1). However a significant effect of the diet was found ($P = 0.012$). After 7 days, meat from C-fed lambs had lower a^* values than meat from both T- and H-fed ones. Moreover, a significant Diet×Time interaction ($P < 0.01$) was found. After 7 days of storage, within each dietary treatment, while meat from lambs fed fresh herbage still retained redness close to that measured at day 0, meat from both C- and T-fed lambs had lower a^* values than those found at day 0. Regardless of dietary treatment, meat yellowness (b^* values; Table 1) increased with time ($P < 0.001$). However diet affected this parameter ($P = 0.02$). After 14 days of storage, meat from lambs given the conventional concentrate had higher b^* values than meat from both herbage-fed and T-fed animals. Moreover, from 7 to 14 days, while yellowness remained stable in meat from both T- and H-fed animals, b^* values increased in meat from C-fed lambs (T×D interaction; $P = 0.009$).

Changes in redness and yellowness over a period of display have been often used to describe meat browning (Mancini and Hunt, 2005; Insausti *et al.*, 2008). However, increases in H^* values over time - resulting from the decreases in a^* relative to b^* - are able to better describe meat discoloration instead of single colour coordinates (Renerre, 2000; Lee *et al.*, 2005). In the present study, hue angle increased with time, regardless of dietary treatment ($P < 0.001$; Table 1). Diet significantly affected this colour descriptor ($P = 0.003$). After 7 days of storage, meat from animals given the conventional concentrate had higher H^* values than that from both T- and H-fed animals. After 14 days, meat from C-fed animals had higher H^* values than meat from H-fed ones, while H^* values in meat from T-fed animals were intermediate and did not differ from those found in meat from both C- and H-fed lambs.

Meat colour changes are related to myoglobin chemistry, whereby the increase in metmyoglobin concentrations, due to the oxidation of the haem pigment, is the main cause of meat browning (Mancini and Hunt, 2005). Regardless of dietary treatment, we found increasing MMb percentages over time ($P < 0.001$; Table 1). Moreover, diet significantly affected metmyoglobin formation ($P = 0.007$). After 7 days, lower MMb formation was found in meat from lambs given herbage compared to C-fed ones. This might be one of the reasons explaining the improved colour stability observed in meat from

lamb fed herbage compared to that from the animals given the conventional tannin-free concentrate. The inclusion of tannins into the concentrate did not result in differing percentages of MMb compared to C diet at any day of analysis.

In conclusion, feeding lambs dietary tannins, by including a tanniniferous extract into a conventional concentrate, were able to extend meat colour stability compared to the same concentrate without the addiction of tannins. Moreover, the protective effect of dietary tannins against meat discolouration was comparable to that obtained by feeding animals exclusively fresh herbage, a diet representing a rich source of natural antioxidants.

Table 1. Colour coordinates and percentages of metmyoglobin of meat over the 14 days of storage.

Time (T)	0			7			14			SE	*P* value		
Diet (D)	C	T	H	C	T	H	C	T	H		T	D	T×D
a*	12.8^{D}	13.1^{D}	11.9^{CD}	5.7^{A}	8.8^{BC}	10.3^{CD}	3.3^{A}	4.6^{A}	6.3^{AB}	0.5	***	*	**
b*	3.9^{A}	3.8^{A}	3.7^{A}	9.8^{B}	7.6^{B}	7.6^{B}	12.6^{C}	9.8^{B}	8.9^{B}	0.4	***	*	**
H*	16.7^{A}	16^{A}	17^{A}	59.6^{CD}	42^{B}	38.1^{B}	75.2^{D}	64.6^{CD}	53.6^{BC}	2.9	***	**	**
MMb%	35^{A}	29^{A}	29^{A}	81^{C}	67^{BC}	58^{B}	77^{BC}	77^{C}	78^{C}	2.9	***	**	ns

$^{A, B, C, D}$ Means within a raw bearing different superscripts are significantly different (P < 0.05)
*ns: not significant; *: P < 0.05; **: P < 0.01; ***: P < 0.001*

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