EFFECT OF FORAGE LEGUME, STOCKING RATE AND CONDENSED TANNINS ON CORRIEDALE LAMB MEAT QUALITY IN URUGUAY

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Background

Meat color, visible fat content and odour are variables that the consumers judge at the time of purchase. However, when meat is being consumed, tenderness, juiciness and flavour became the main characteristics. Meat quality, as a general concept, is difficult to define, because it can have different meanings for different consumers. Given this consumer behaviour variability, it is not common to study this concept based on just one characteristic of meat quality. Instead, it should be considered on a broader manner, taking into account a number of characteristics measured objectively. Despite of this approach of scientific studies, one must consider that for consumers, the general concept or impression is what really matters (Purchas, 1994). In the actual export markets under high competitive pressure and particularly in the food industry around the world, marketing strategies have to be based on solid scientific means to certify and assure food safety and product quality. It is also known, that other attributes associated with the environment sustainability, animal welfare and social aspects, where animal are produced, constitute other important aspects of the promotion strategies and development of market niches for each country (Montossi *et al.*, 2003).

Objectives

The purpose of this study was to evaluate the effects of forage legume (*Lotus pedunculatus* cv. Maku, *Lotus subbliflorus* cv. El Rincón, *Lotus corniculatus* cv. Draco and *Trifolium repens* cv. LE Zapicán), condensed tannins (CT) and stocking rates (8 and 12 lambs/ha) on meat quality in Uruguayan Corriedale lambs.

Materials and methods

Description of the experiment

One hundred and twenty eight castrated male Corriedale lambs (9 months old), born in August-September 2000, were used for this study. At the beginning of the experiment, the average liveweight (LW) and condition score (CS) were 23,8 ± 2,1 kg (fasted) and 2,2 ± 0,3 units, respectively. The selected lambs were divided into balanced groups according to LW and CS. Half of the lambs received two oral administrations (0730 and 1730 hours) of polyethylene glycol (PEG; MW 6000) to inactivate CT (2 g of PEG per 1 g of CT), whilst the remaining lambs received oral administration of water. PEG supplementation was used to study the interaction between condensed tannins (CT) and proteins (Jones and Mangan, 1977; Barry and Manley, 1986; cited by Barry *et al*., 2001), because of its capacity to make strong binds with CT.

Animal measurements

Objective parameters of meat and carcass quality were measured on half of the animals (n=64): meat temperature and pH at 1, 3 and 24 hours *pos mortem*, between 12th and 13th rib (*Longissimus lumborum* muscle; LL). The muscle pH was measured using a hand-held pH meter (Orion A 230) with a probe type electrode (BC 200, Hanna Instruments), standardized against two pH buffers (4 and 7). The probe was cleaned with alcohol and rinsed with water between uses. The temperature was determined by a thermometer (Barnant 115) with stainless steel thermocouple (type E). Muscle and fat color measurements were made using a Minolta Colorimeter (model C-10). They were recorded in triplicate from the approximate geometric center of the exposed LL muscle at the 13th rib, after 24 hours *pos mortem*, taking the readings of L*, a* and b* parameters, according to the Hunter system.

A portion of the LL was removed from the left side of carcasses, labeled, vacuum-packaged, and measured for shear force after 10 days of aging at 2 - 4 °C. The samples were cooked by immersion within a plastic bag in a water bath at an internal temperature of 70°C for 75 min. The internal temperature was monitored using type E thermocouples placed in the approximate geometric center of the sample. Six cores (2,54 cm in

diameter) parallel to the muscle fiber orientation were removed from each sample. A single peak WBSF measurement was obtained for each core using a WBSF machine (G-R Electric Manufacturing Co, Manhattan, KS). Individual-core peak shear force values were averaged to assign a mean peak WBSF value to each sample. Further procedures concerning measurements have been described in Montossi *et al.* (2003).

Statistics

The animal information was analyzed using the statistical package SAS (SAS, 2000), based on Split-Split-Plot design using 2 blocks, with the 4 forage species (*Lotus corniculatus* cv. INIA Draco, *Lotus pedunculatus* cv. Maku, *Lotus subbiflorus* cv. El Rincón and *Trifolium repens* cv. LE Zapicán), being the main plot arranged in a 2 x 2 factorial structure. Stocking rate (SR; 8 or 12 lambs/ha) was treated as the split-plot factor, while PEG (CT inactivated or activated) was used as the split-split-plot factor. All data were initially tested for normality and homogeneity of variance. Before the statistical analysis was performed, some variables (tenderness, temperature, pH, meat and fat color) were normalized by 3√, Ln or 1/Ln correction factors. Liveweight gain (LWG) was adjusted by covariance for initial live weight. Carcass fatness (estimated by GR point) was evaluated using hot carcass weight (HCW) as a co-variate.

Results and Discussion

Animal performance and carcass quality

Animal performance and carcass quality traits are presented in Table 1. Lambs grazing *Trifolium repens* cv. LE Zapicán (white clover; WC) reached the highest liveweight gain (LWG; g/d), intermediate values were found for *Lotus corniculatus* cv. INIA Draco (D) and *Lotus pedunculatus* cv. Maku (M) lambs, and the lowest value was for lambs grazing on *Lotus subbiflorus* cv. El Rincón (R) swards. These results of LWG between animals grazing different species caused differences in final liveweight (FLW), hot carcass weight (HCW), cold carcass weight (CCW) and fat cover (GR). Stocking rate (SR) affected animal performance and carcass traits, where animals of the lower SR obtained higher values than animals of higher SR. PEG supplementation did not affect these variables, probably caused by the high quantity and quality of the forage offered (Barry *et al.*, 2001).

Meat quality

It is desirable to decrease muscle temperature after slaughter in order to reduce the losses of proteins and to inhibit bacterial growth, but this reduction has to be slow to prevent muscle fibre shortening (cold shortening)(Brito, 2002). Table 2 shows the results of muscle temperature and pH at 1, 3 and 24 hours *post mortem*. Spp affected significantly temperature at 1 and 3 hours. Despite the differences found between SR in fat cover (GR), there was no effect of this factor on the reduction of the temperature *post mortem*, probably caused by the small differences shown. PEG supplementation did not affect temperature measurements. Muscular pH of alive animals is between 7.1 and 7.3, reducing itself down to 5.5-5.7 at 48 hours *post mortem* (Garrido and Bañón, 2000). In this study, the differences recorded in temperature at 1 and 3 hours between forage species did not cause *Longissimus lumborum* pH differences (1, 3 and 24 hours *post mortem*). SR and PEG supplementation did not affect pH measurements.

Consumer preferences are greatly affected by meat tenderness, being considered as the most important characteristic of meat quality and determinant of the repetition of purchasing (Brito *et al*., 2002). Tenderness results, obtained by shear force measurements (SF; kgF) of *Longissimus lumborum* muscle, were not affected by the effect of any of the evaluated factors (Table 3). These results could be due to the similar pH and temperature reduction shown by the different treatments (Brito *et al*., 2002). Anyway, the small differences found between treatments applied on tenderness, are strongly influenced by the experiment protocol used to determine the value of shear force, which includes 10 days of meat ageing. This process allows the tenderization of the muscular fibers, reducing existing differences caused by initial meat tenderness or some processes applied pre, during or after slaughter (Brito *et al*., 2002). Camesasca *et al*. (2002) did not find differences in meat tenderness despite the differences in temperature and pH. This suggests that the 10 days of ageing at 2-4 °C would explain these results, given the importance that this process has in reducing differences in meat tenderness (Brito *et al*., 2002; Koohmaraie *et al*., 1995, cited by Camesasca *et al*., 2002).

The findings on temperature, pH and tenderness (Tables 2 and 3), are similar to those obtained by Brito *et al*. (2002) for lamb carcasses (male and females) of different genotypes and less than 12 months old, reared with different nutritional regimes under grazing conditions. In the case of pH, the values are also similar to those obtained by Wheeler and Koohmaraie (1994). Both factors, in addition to the ageing process, and the high liveweight gains during the experiment, could be explained by the low values of SF obtained, which were very similar to those reported by Camesasca *et al*. (2002). Bickerstaffe (1996), cited by Brito *et al*. (2002), suggested that the values of lamb meat tenderness standardized by the meat industry of the United States and New Zealand, to maintain or access to new markets, has to be less than 5 kgF in terms of shear force.

According to the results obtained in the present experiment, these animals would be eligible to those important markets. Adams and Huffman (1972), cited by Osório and Sañudo (1996), reported that the meat color is one of the most important consumer attributes, and is the most relevant quality factor that the consumer considers at the time of purchase. Color of meat is affected by pre-slaughter (animal species, age, sex and feeding system, etc, Albertí, 2000), as well as post-slaughter factors (cooling conditions, pH reduction, etc.; Brito *et al*., 2002). Table 4 shows the results of the effect of Spp, SR and PEG on muscle and fat color. Spp and PEG did not have a significant effect on the parameters of lightness (L*), relative redness (a*) or yellowness (b*) of muscle. However, SR significantly affected muscle lightness (L*m), being higher in the SR of 12 lambs/ha, but did not affect the parameters a* and b*.
Channon and Leury (1992), comparing different diets (*Trifolium yannicum vs. Lolium rigidum*), did not find differences on muscle pH (*L. lumborum*) and lightness, but the treatments affected parameters a* and b*. In another work made by the same authors, animals fed at maintenance level and well fed later, did not show differences in meat color in comparison with animals without restrictions. Due to the lack of information gather from R treatment in fat color, the comparison is restricted to the remaining treatments. The parameters of fat a* and b* did not show differences of statistical significance between the evaluated factors. On the other hand, L* was affected significantly by forage species, but not by the remaining evaluated factors. WC achieved a higher value than M, and D did not have differences with both species. The values of muscle and fat L*, a* and b* are similar to the results reported by Brito *et al*. (2002) in Uruguayan national evaluations on lambs with different nutritional regimes.

Conclusions

For the conditions imposed in this study, under grazing conditions with adequate feeding levels and meat aging period of 10 days, lambs meat quality attributes were not substantially affected by the type of legume, feeding regimes and PEG supplementation used. The values of temperature, pH and tenderness found in this study, and those provided by Montossi *et al*. (2003) in a national sheep meat quality audit, suggest that the meat produced by these Uruguayan Corriedale lambs would be eligible to the most important external markets.

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Table 1. Effect of forage species (Spp), stocking rate (SR) and PEG supplementation (PEG) on animal performance and carcass quality traits.

Variable	Species (Spp)					Stocking rate (SR)			PEG		
	D	M	R	WC	P	12	8	P	No	Yes	P
LWG (g/d)	176[b]	182[b]	150[c]	221[a]	**	171[b]	193[a]	**	181	183	ns
FLW (kg)	39.8[b]	40.5[b]	37.1[c]	44.7[a]	**	39.4[b]	41.7[a]	**	40.4	40.7	ns
HCW (kg)	19.4[b]	19.3[b]	16.3[c]	22.4[a]	**	18.8[b]	19.9[a]	**	19.3	19.4	ns
CCW (kg)	19.0[b]	18.8[b]	15.9[c]	22.0[a]	**	18.4[b]	19.4[a]	*	18.9	18.9	ns
GR (mm)	9.2[b]	8.4[c]	4.5[d]	12.6[a]	**	7.5[b]	9.8[a]	**	8.9	8.5	ns

ns: not significant (P>0.05), *: P<0.05 and **: P<0.01.
[a, b, c y d]: means with different letters within each variable are statistically different (P<0.05).
D: *L. corniculatus* cv. INIA Draco; M: *L. pedunculatus* cv. Maku; R: *L. subbiflorus* cv. El Rincón; WC: *T. repens* cv. LE Zapicán; LWG: liveweight gain; FLW: final liveweight; HCW: hot carcass weight; CCW: cold carcass weight; GR: fat cover.

Table 2. Effect of forage species (Spp), stocking rate (SR) and PEG supplementation (PEG) on meat temperature and pH *post mortem*.

Variable	C F	Species (Spp)					Stocking rate (SR)			PEG			Spp x SR	Spp x PEG	SR x PEG	Sppx SRx PEG
		D	M	R	WC	P	12	8	P	No	Yes	P				
Temp.1	=	23.6[b]	23.2[b]	20.7[c]	26.1[a]	**	23.3	23.5	ns	23.5	23.2	ns	ns	ns	ns	ns
Temp.3	R[3]	16.8[a]	17.0[a]	14.4[b]	17.7[a]	*	16.0	16.9	ns	16.5	16.4	ns	ns	ns	ns	ns
Temp.24	=	4.2	4.4	4.2	4.2	ns	4.2	4.4	ns	4.3	4.3	ns	ns	ns	ns	ns
pH 1	Nl	6.4	6.4	6.5	6.4	ns	6.4	6.4	ns	6.4	6.4	ns	ns	ns	ns	ns
pH 3	Nl	6.2	6.1	6.2	6.2	ns	6.2	6.2	ns	6.2	6.1	ns	ns	ns	ns	ns
pH 24	Nl	5.8	5.8	5.8	5.8	ns	5.8	5.8	ns	5.8	5.8	ns	ns	ns	ns	ns

ns: not significant (P>0.05), *: P<0.05 and **: P<0.01.
a, b, c y d: means with different letters within each variable are statistically different (P<0.05).

Table 3. Effect of forage species (Spp), stocking rate (SR) and PEG supplementation (PEG) on meat tenderness.

Variable	CF	Species (Spp)					Stocking rate (SR)			PEG			Spp x SR	Sppx PEG	SRx PEG	Sppx SRx PEG
		D	M	R	WC	P	12	8	P	No	Yes	P				
SF (kgF)	Nl	1.63	1.60	1.71	1.60	ns	1.65	1.61	ns	1.61	1.66	ns	ns	ns	ns	ns

ns: not significant (P>0.05), *: P<0.05 and **: P<0.01.

Table 4. Effect of forage species (Spp), stocking rate (SR) and PEG supplementation (PEG) on parameters of muscle and fat color.

	CF	Species (Spp)					Stocking rate (SR)			PEG			Spp x SR	Spp x PEG	SR x PEG	Spp x SR x PEG
		D	M	R	WC	P	12	8	P	No	Yes	P				
L*m	l/Nl	36.4	37.2	36.7	38.2	ns	37.7[b]	36.5[a]	*	36.6	37.6	ns	ns	-	-	-
a*m	Ln	19.8	20.1	19.6	19.8	ns	19.8	19.8	ns	19.8	19.8	ns	ns	-	-	-
b*m	R[3]	8.5	8.6	7.8	8.4	ns	8.3	8.3	ns	8.1	8.4	ns	ns	-	-	-
L*f	Nl	73.0[ab]	70.8[b]	-	75.0[a]	*	72.1	76.0	ns	73.2	72.6	ns	-	-	-	-
a*f	R[3]	4.5	3.9	-	3.6	ns	4.0	4.0	ns	3.9	4.1	ns	-	-	-	-
b*f	R[3]	10.6	11.1	-	10.4	ns	10.1	11.3	ns	10.7	10.7	ns	-	-	-	-

ns: not significant (P>0.05), *: P<0.05 and **: P<0.01.
a, b, c y d: means with different letters within each variable are statistically different (P<0.05).