Relationship between flavour volatiles and eating quality of lamb

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In lamb production on the island of Ireland there is a trend towards raising ram lambs as opposed to castrated lambs, for welfare reasons and for improved efficiency because rams usually reach slaughter weight faster. However meat from ram lambs is often perceived by the industry to be of lower quality due to anecdotal evidence of a ram taint. It is important to determine whether this perceived taint is real and to identify the cause with a view to developing mechanisms to minimise it. Previous studies have shown that a range of odour compounds may be responsible for the off-odours associated with lamb meat. A joint project between the Agri-Food & Biosciences Institute (AFBI), University College Dublin and Teagasc aims to establish the factors affecting the occurrence of any off-odour in entire male lambs. This paper presents the results of an experiment, conducted at AFBI to determine the effect of forage diet, breed and gender of the lambs on the flavour quality of the meat. Sensory profiling analyses, using a trained panel, on the loins from 272 lambs, reared on a range of forage and concentrate diets are currently being conducted at AFBI. Results from Year 1 identified a number of significant attributes from animals across these treatments. These included a 'greasy' and 'meaty' aroma associated with breed, tenderness related to gender, and also gender:breed:diet interactions. Gas chromatography-olfactometry analysis on selected treatments has also been conducted. Initial analysis has indicated possible compounds that may contribute to a less desirable odour of lamb meat from some treatments.

The type of condensed tannins affected differently growth and meat lipid oxidation of light lambs

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The aim of this study was to assess the effect of the feeding during lactation and the inclusion of condensed tannins (CT) in the concentrate during the fattening period on productive parameters and on meat lipid oxidation of light lambs. At parturition, 63 Rasa Aragonesa ewe-lamb pairs were randomly distributed in 3 treatments. During the lactation period, one group was housed indoors and received a total mixed ration (TMR), a second group was stocked on alfalfa (Medicago sativa) paddocks (Alfalfa) and the third group was stocked on sainfoin (Onobrychis viciifolia) paddocks (Sainfoin). At day 42, the lambs were weaned and half of the lambs of each feeding treatment was fed a commercial concentrate (Control; 11.9 MJ/kg FM, 17.5% crude protein) or a commercial concentrate with 5% of Quebracho (QUE, SYLVAFEED ByPro Q, Spain, with 75% of CT; 11.7 MJ/kg FM, 17.5% crude protein). When lambs reached the target slaughter weight (22-24 kg BW), they were slaughtered. Carcass characteristics were registered and samples of the Longissimus thoracis et lumborum muscle were obtained to study the intramuscular fat content and the lipid oxidation of the meat. The feeding treatment during lactation slightly affected weight gains and BW at slaughter of lambs. Sainfoin treatment tended to improve the BW at slaughter ($P=0.09$). TMR lambs had the heaviest carcasses and greater dressing percentage and kidney fat depots, Sainfoin lambs intermediate, and Alfalfa lambs the lowest. Regarding lipid oxidation of meat, Sainfoin lambs presented the lower level from 5 d until 14 d of storage ($P<0.05$). The inclusion of Quebracho in the concentrate tended to improve the weight gains during fattening period and the BW at slaughter ($P<0.1$) at the same age ($P>0.05$) but did not affect lipid oxidation.

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INTRODUCTION

Traditional lamb meat production in Mediterranean countries is based on:

LIGHT LAMB

BW < 25 kg

Age < 90 d

- During lactation, ewes and lambs are stalled indoors
  - Ewes fed hay or straw + concentrates
  - Lambs fed milk (45-50 days old)
- After weaning, lambs fed high-concentrate diet

To obtain a homogenous product " Light lamb of Aragon" , Protected Geographical Indication (PGI)

INTRODUCTION

The former is the usual intensive system in Mediterranean area

✓ Grazing good quality forages, as alfalfa, allows a good performance of lactating ewes (Álvarez-Rodriguez et al. 2010)

Medicago sativa

✓ Grazing Sainfoin could be an interesting alternative as it has high protein content and condensed tannin.

Onobrychis viicifolia

- Multiannual legumes
- Widely used in Mediterranean areas

INTRODUCTION

Oxidation is one of the main reason for quality deterioration in meat

To postpone it, the addition of antioxidant has emerged as a strategy

✗ Synthetic

✓ Natural

Quebracho ← Condensed tannins

OBJETIVE

The aim of this study was to evaluate:

→ The effect of the feeding treatment during **LACTATION** period, (alfalfa, sainfoin, indoor)

→ The inclusion of Quebracho in the concentrate during **FATTENING** period

On the **performances** of light lambs and on the **lipid oxidation** of meat

MATERIAL AND METHODS

ZARAGOZA

MATERIAL AND METHODS

MATERIAL AND METHODS

Lactation period

After lambing, ewe-lamb pairs were ramdomly assigned according to ewe´s BW and BCS to one of three treatments:

Ewes and lambs rotationally grazed paddocks

They were changed to a new paddock fortnightly to ensure that the stubble height was above 10 cm

Ewes and lambs were housed and were fed with a total mixed ration

MATERIAL AND METHODS

Fattening period: 2 type of concentrate

Weaning → Slaughter 22-24 kg

CONTROL	QUEBRACHO 5%
11.9 MJ/kg FM, 17.5% CP	11.7 MJ/kg FM, 17.5% CP

MATERIAL AND METHODS Controls and analysis

Body weight

Lambing 0 d → Weaning 42 d → Slaughter 70 d

Lactation | ADG | Fattening

Concentrate intake

MATERIAL AND METHODS Controls and analysis

Hot carcass weight

Kidney fat

Cold carcass weight

Dressing percentage

Intramuscular Fat

Lipid oxidation: TBARS

Placed in 6 trays

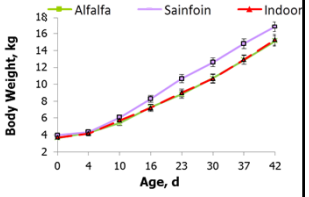
Darkness at 4 ºC

2 5 7 9 12 14 days

RESULTS AND DISCUSSION: Production parameters

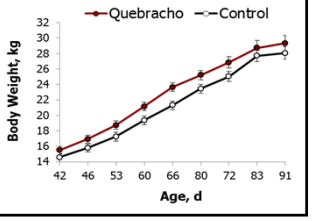
Lactation period

- ✓ ADG: > Sainfoin †
- ✓ BW at weaning: NS
- ✓ Concentrate intake: > Indoor



Fattening period

- ✓ ADG: > Quebracho †
- ✓ BW at slaughter: > Quebracho †
- ✓ Concentrate intake: > Quebracho *



RESULTS AND DISCUSSION: Carcass characteristics

	Lactation			Fattening		P-value	
	Alfalfa	Sainfoin	Indoor	QUE	Control	L	F
Hot carcass weight, kg	10.7^{b}	10.8^{b}	11.4^{a}	11.1	10.8	0.03	0.16
Cold carcass weight, kg	10.4^{b}	10.5^{b}	10.9^{a}	10.9	10.5	0.03	0.10
Dressing percentage, %	45.0^{b}	45.7^{b}	47.8^{a}	46.4	46.0	0.001	0.57
Kidney Fat, g	124^{b}	140^{b}	227^{a}	167	160	0.001	0.66

RESULTS AND DISCUSSION:

Intramuscular fat content

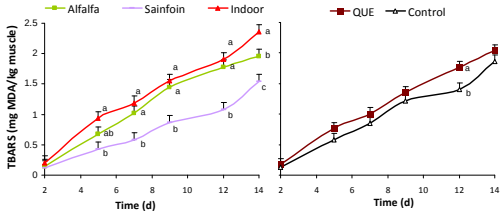
Lactation period

Indoor > Alfalfa
Sainfoin

Fattening period

NO EFFECT

Lipid oxidation



CONCLUSIONS:

- The diet during the lactation period was the **most important** effect
- Lamb with their dams in sainfoin paddocks during lactation is an advisable system:
  - Improves slightly weight gains
  - Extends the meat shelf life
- The inclusion of Quebracho in the concentrate during the fattening period:
  - Tended to increase lamb´s weight
  - No effect on meat shelf life

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P u b l i s h e r s

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Abstract

The aim of this study was to assess the effect of the feeding during lactation and the inclusion of condensed tannins (CT) in the concentrate during the fattening period on productive parameters and on meat lipid oxidation of light lambs. At parturition, 63 Rasa Aragonesa ewe-lamb pairs were randomly distributed in 3 treatments. During the lactation period, one group was housed indoors and received a total mixed ration (**TMR**), a second group was stocked on alfalfa (*Medicago sativa*) paddocks (**Alfalfa**) and the third group was stocked on sainfoin (*Onobrychis viciifolia*) paddocks (**Sainfoin**). At day 42, the lambs were weaned and half of the lambs of each feeding treatment was fed a commercial concentrate (**Control**; 11.9 MJ/kg FM, 17.5% crude protein) or a commercial concentrate with 5% of Quebracho (**QUE**, SYLVAFEED ByPro Q, Spain, with 75% of CT; 11.7 MJ/kg FM, 17.5% crude protein). When lambs reached the target slaughter weight (22-24 kg BW), they were slaughtered. Carcass characteristics were registered and samples of the *Longissimus thoracis* et *lumborum* muscle were obtained to study the intramuscular fat content and the lipid oxidation of the meat.

The feeding treatment during lactation slightly affected weight gains and BW at slaughter of lambs. Sainfoin treatment tended to improve the BW at slaughter (P=0.09). TMR lambs had the heaviest carcasses and greater dressing percentage and kidney fat depots, Sainfoin lambs intermediate, and Alfalfa lambs the lowest. Regarding lipid oxidation of meat, Sainfoin lambs presented the lower level from 5 d until 14 d of storage ($P < 0.05$). The inclusion of Quebracho in the concentrate tended to improve the weight gains during fattening period and the BW at slaughter ($P<0.1$) at the same age ($P>0.05$) but did not affect lipid oxidation.

Key words: Sainfoin, Alfalfa, Quebracho, carcass characteristics.

1. Introduction

In Mediterranean areas, light lamb production is based on concentrates from weaning to slaughter and ewe's management has been intensified as herd size is growing. However, grazing good quality forages, as alfalfa (*Medicago sativa*) allows a good performance of lactating ewes (1). Sainfoin (*Onobrychis viicifolia*) grazing could be an interesting alternative as it has high protein and condensed tannins contents. Condensed tannins are secondary compound of plants widespread in the plant kingdom and they have been studied to reduce methane production (2). Moreover, condensed tannins are natural antioxidants. Oxidation is one of the main reasons for quality spoilage in meat products. To postpone it, the addition of antioxidants has emerged as a strategy. Natural or synthetic antioxidants can be added to the animal´s diet, which is one of the most effective ways to inhibit lipid oxidation in fat (3). The use of natural antioxidants is more desirable, as synthetic ones have been associated with potential human risks and consumer rejection (4). However, condensed tannins have a complex and varied structure and their effects depend on this structure and dose given to the animal.

The aim of this study was evaluate the effect of the feeding treatment during lactation and the inclusion of CT from Quebracho in the concentrate during fattening on the performance of light lambs and on the lipid oxidation of meat.

2. Materials and Methods

The experiment was conducted in the facilities of CITA Research centre in Zaragoza. A flock of 207 Rasa Aragonesa ewes was mated at the end of October by natural service. Ewes were stalled around parturition. From this flock, the multiparous single-bearing ewes (n=63) and their male lambs (n=63) were selected for the experiment. After lambing, ewe-lamb pairs were randomly assigned according to ewe's body-weight (BW: average 46.6 kg) and body condition score (BCS: average 2.43) to one of the next three treatments during the lactation period:

- TMR: Ewes and lambs were housed and received a total mixed ration *ad libitum* (n=21).
- Sainfoin: Ewes and lambs rotationally grazed in sainfoin paddocks (n= 21).
- Alfalfa: Ewes and lambs rotationally grazed in alfalfa paddocks (n=21).

All suckling lambs had access to a commercial concentrate in order to avoid digestive problems after weaning (40-45 days of age). From weaning to slaughter (at 22-24 kg BW), half of lambs of each treatment during the lactation period was fed with a commercial concentrate (11.9 MJ/kg FM, 17.5% crude protein; **Control**). The other half was fed with a commercial concentrate with 5% of Quebracho (SYLVAFEED ByPro Q, Adial Nutrition. Girona, Spain), with 75% of condensed tannins (11.7 MJ/kg FM, 17.5% CP; **QUE**). The lambs of each treatment were allocated randomly in two pens. Water and mineral blocks were always offered *ad libitum*.

Lambs were weekly weighed at 9 a.m. Average daily gains (ADG) were calculated. Concentrate intake was recorded weekly by pen. When the lambs reached the target slaughter weight, they were slaughtered weekly, according to guidelines of the Council Directive 86/609/EEC (European Comunities, 1986) in the experimental abattoir of the Research Center. Just after slaughter, hot carcass weight (HCW) was registered and kidney fat depots were weighed. Carcasses were hung by the Achilles tendon and chilled at 4 ºC for 24 h in total darkness. After this time, cold carcass weight (CCW) was registered and dressing percentage was calculated (CCW/BW at slaughter). Then, the *Longissimus thoracis et lumborum* (LTL) muscle was extracted and sliced into seven, 2.5-cm thick samples, one to determine the fat intramuscular (Ankom, NY, USA) and the others to determine the lipid oxidation during storage. Six samples were randomly placed in 6 trays, wrapped with oxygen-permeable PVC film and kept in darkness (4 ºC) for 2, 5, 7, 9, 12 and 14 days. When each storage time finished, the samples were individually vacuum-packed and frozen (-20 ºC) until lipid oxidation analysis.

To determine the lipid oxidation, TBARS analysis was carried out as described (5), results were expressed as mg of Maldonaldehyde (MDA) per kg of muscle.

Data were analysed using the SAS statistical software (SAS V.9.3). Weight gains, fattening length, concentrate intake during fattening and carcass characteristics were analysed through analysis of variance with a general linear model (GLM procedure), with the type of feeding during lactation, the inclusion of QUE in the concentrate and its interaction as fixed effects. Body weight and lipid oxidation of LTL muscle were analysed with a mixed model (MIXED procedure) using mixed models for repeated measures including the feeding during lactation, the inclusion of QUE in the concentrate, the storage time and their interactions as fixed effects and the lamb as a random effect. Results were reported as least square means and their

associated standard errors (SE). Multiple comparisons among treatments were performed by the Tukey's method. Differences were significant for P<0.05 and tendencies for P<0.10.

3. Results and discussion

The interaction between the feeding during the lactation and the inclusion of QUE in the concentrate during the fattening period was not significant. Thus, results are presented for the main effects separately.

3.1. Production parameters

During lactation, parameters were similar among treatments (P>0.05), except for average daily gain (ADG) (P<0.10). Sainfoin lambs had greater ADG than TMR lambs (P<0.05), whereas Alfalfa lambs had intermediate values. In the fattening period, the feeding in lactation period did not have effect on lamb performance (Table 1). The Slaughter BW, however, tended to be different between Sainfoin and their counterparts (P<0.10).

Table 1. Effect of the feeding during lactation (L) and the inclusion of Quebracho in the concentrate during fattening (F) on lamb productive parameters

	Lactation			Fattening			P-value	
	Alfalfa	Sainfoin	TMR[1]	QUE[2]	Control	SE	L	F
Lactation period								
Birth BW, kg	3.9	4.1	3.9	4.0	4.0	0.3	0.67	0.95
Weaning BW, kg	14.6	15.7	15.4	15.5	15.0	1.0	0.38	0.46
ADG, g/d	293ab	317a	283b	301	291	22	0.07	0.33
DMI, g/d	35	35	108	-	-	-	-	-
Age at weaning, d	42	41	43	42	42	2	0.55	0.50
Fattening period								
Slaughter BW, kg	22.9y	23.5x	22.9y	23.4x	22.9y	0.40	0.09	0.06
ADG, g/d	288	275	276	289x	270y	16	0.54	0.08
DMI, g/d	818	840	845	900x	768y	0.04	0.92	0.05
Age at slaughter, d	70	69	70	68	71	4	0.91	0.33
Length, d	28.3	27.4	27.0	26.0	29.1	3.93	0.93	0.24

[1]Total mixed ration; [2] with 5% of Quebracho; Within a parameter and main effect, a,b denote differences at P<0.05 and x,y denote differences at P<0.10

Regarding the inclusion of QUE in the fattening concentrate, it was observed an increase of DMI (P=0.05), ADG and slaughter BW (P<0.10) were observed. In this sense, in grazing lambs, weight gains increased with the inclusion of QUE in a low protein concentrate but not in a high protein concentrate because QUE did not contribute any further to protein supply in the small intestine (6).

3.2. Carcass characteristics

Carcass characteristics of lambs were affected by the feeding during lactation but not by the inclusion of CT in the concentrate during the fattening period (Table 2). Carcass weights and dressing percentage were greater for TMR, intermediate for Sainfoin, and lighter for Alfalfa lambs (P <0.05). These results can be related to the effect of forage increasing digestive tract size, resulting in a lower dressing percentage (7). TMR lambs had greater deposition of kidney

fat than Alfalfa and Sainfoin lambs (P<0.001), which could be related to the greater intake of concentrate during lactation (Table 1). In that sense, some authors observed that lambs fed concentrates presented also higher internal fat contents than forage-fed lambs (8), which could have contributed to the greater dressing percentage (9).

Table 2. Effect of the feeding during lactation (L) and the inclusion of Quebracho in the concentrate during fattening (F) on carcass characteristics.

	Lactation			Fattening			P-value	
	Alfalfa	Sainfoin	TMR[1]	QUE[2]	Control	SE	L	F
HCW[3], kg	10.6b	11.1ab	11.3a	11.1	10.8	0.3	0.03	0.16
CCW[4], kg	10.3b	10.8ab	10.9a	10.9	10.5	0.3	0.03	0.10
DP[5], %	45.0	45.7ab	47.8a	46.4	46.0	1.1	0.001	0.57
Kidney Fat, g	124b	140b	227a	167	160	25	0.001	0.66

[1]Total mixed ration; [2] with 5%of Quebracho; SE = Standard error; [3] Hot carcass weight; [4]Cold carcass weight; [5] dressing percentage. Within a parameter and main effect, a,b denote differences at P<0.05

3.3. Meat pH, intramuscular fat and Lipid oxidation

Meat pH was not affected by the feeding treatments during lactation or fattening with an average value of 5.56 (±0.03). Intramuscular fat content was greater for TMR than for Alfalfa and Sainfoin lambs (11.65, 9.84 and 9.57 %, respectively; P<0.001); but it was not affected by the inclusion of QUE in the concentrate (P>0.05). Lipid oxidation was affected by the interaction between feeding during lactation and storage time (P < 0.001) but not by the inclusion of QUE in the concentrate (Figure 1).

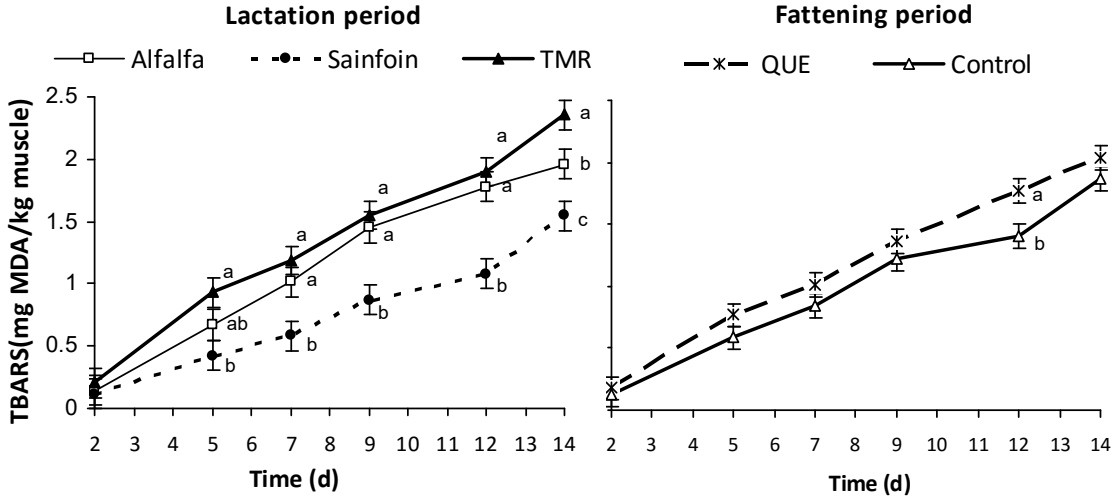

Figure 1. Effect of the feeding during lactation and the inclusion of QUE in the concentrate during fattening on lipid oxidation during meat storage.

Within a day of storage and main effect, different letters denote differences at P < 0.05

Alfalfa and TMR lambs had similar lipid oxidation (P>0.05) until 14 d, when Alfalfa had lower values than TMR lambs (P<0.05), and sainfoin lambs presented the lowest values of TBARS from 5 to 14 d (P<0.05), probably due to the presence of phenolic compounds that strongly reduce meat lipid oxidation over time of storage or display (10). Alfalfa contains vitamin E that delays the meat lipid oxidation (5), however it does not content noticeable amounts of CT, which could explain the lack of effect of the grazing during lactation. The absence of the effect of the inclusion of 5% of Quebracho in the concentrate during fattening period on lipid oxidation is in line with Luciano et al. (11). They reported that an inclusion of 8.96% of

Quebracho during fattening period had no effect on lipid oxidation, although it affected muscle antioxidant capacity (12).

3.4. Conclusions

Sainfoin grazing of lambs with their dams during lactation period improved slightly weight gains during this period and had a positive effect on the meat shelf life. It would be interesting to study the use of sainfoin in the fattening period. In our conditions, the addition of Quebracho in the fattening period tended to increase lamb's weight gains; however, it did not have any effect on the meat shelf life. Future studies should be done to analyse the antioxidant capacity of the muscle in lambs fattened with different doses of Quebracho.

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