Digestive tract contents in light lambs as affected by forage inclusion and weaning

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Abstract. The effects of forage inclusion (alfalfa-fed with concentrate supplementation, ALF, *vs* concentrate-fed, CONC) and milk supply (suckling until 13 kg, W, *vs* until slaughter, S) on the digestive tract contents of Rasa Aragonesa light lambs (n=32, target slaughter weight of 23.0 kg) were analysed in a 2 x 2 factorial design. Immediately after slaughter (without fasting period), the contents of each gastrointestinal compartment were separated and weighed and pH of reticule-rumen and caecum were measured. Age at slaughter and empty body-weight did not differ (P>0.05) among treatments (94 days and 19.9 kg). Reticule-rumen content was similar in CONC lambs (1749 g) but it was higher (P<0.05) in ALF-W than in ALF-S (2174 *vs* 1385 g). The abomasum content did not differ (P>0.05) among treatments (188 g), nor did the small intestine content (421 g, P>0.05). The caecum content was similar in CONC (221 g) but it was greater (P<0.05) in ALF-W than in ALF-S (408 *vs* 231 g). The large intestine content was lower (P<0.001) in CONC than in ALF (118 *vs* 181 g). Overall digestive tract content was similar in CONC (2667 g) but it was greater (P<0.05) in ALF-W than in ALF-S (3581 *vs* 2378 g). Weaned but not suckling lambs raised on alfalfa filled more their digestive tracts than the rest, which also involved a more buffered digestive environment.

Keywords. Light lambs – Grazing – Concentrate – Intake – Performance.

Le contenu du tractus digestif des agneaux légers influencé par l'inclusion de fourrage et par la sevrage

Résumé. *Les effets de l'inclusion de fourrage (luzerne avec supplémentation en concentré, ALF,* vs *concentré, CONC) et de l'apport de lait (allaitement jusqu'à 13 kg, W,* vs *jusqu'à l'abattage, S) sur le contenu du tractus digestif d'agneaux légers (n=32, 23,0 kg) de race Rasa Aragonesa ont été analysés selon un dispositif factoriel 2 x 2. Immédiatement après l'abattage (sans période de jeûne), les contenus de chaque compartiment gastro-intestinal ont été séparés et le pH du réticulo-rumen et du caecum a été mesuré. L'âge à l'abattage et le poids de la carcasse n'ont pas été affectés (P>0,05) par les traitements (94 jours et 19,9 kg). Les agneaux soumis au régime CONC (1749 g) ont le même (P>0,05) contenu du réticulo-rumen qui a été plus important (P<0,05) avec ALF-W qu'avec ALF-S (2174* vs *1385 g). Le contenu de l'abomasum et de l'intestin grêle n'a pas varié (P>0,05) avec les différents traitements (188 g et 421 g). Le contenu du caecum n'a pas été affecté (P>0,05) par le régime (221 g) mais a été plus important (P<0,05) qu'avec ALF-W qu'avec ALF-S (408* vs *231 g). Le contenu du gros intestin est plus faible (P<0,001) avec CONC qu'avec ALF (118* vs *181 g). Le contenu du tractus digestif n'a pas été affecté avec CONC (2667 g) mais a été plus important (P<0,05) avec ALF-W qu'avec ALF-S (3581* vs *2378 g). Au contraise des agneaux sous-mères, les agneaux sevrés recevant des régimes à base de luzerne ont un taux de remplissage du tractus digestif plus élevé que celui des autres agneaux. Ils ont aussi un meilleur environnement digestif plus tamponé.*

Mots-clés. *Agneaux légers – Pâturage – Concentré – Ingestion – Performance.*

I – Introduction

Lamb production in Spain (second-ranked in the European Union) is based on young lambs from hardy genotypes which are slaughtered at 20–24 kg body-weight (BW) ("Ternasco" or "Recental" commercial category) to produce light carcasses. The most common lamb feeding system is milk from dams until 45 to 55 day-old and thereafter a concentrate-based diet.

This production system does not take advantage of the specific digestive traits of ruminants. In earlier works, it was demonstrated that light lambs could be raised with their dams on mountain pastures (Álvarez-Rodríguez *et al.*, 2007; Joy *et al.*, 2008) with minimum detrimental effects on their average daily gains (ADG) compared to their indoor weaned concentrate-fed counterparts. Even though lamb rumen size increases significantly after two months of age (Large, 1964) (close to the target slaughter weight), lambs of these experiments followed the grazing patterns of ewes since 3-week-old and increased their grazing duration from 2 to 6 hours throughout the first two months of lactation (Álvarez-Rodríguez *et al.*, 2007). However, we could not differentiate the effects of forage intake from the effects of milk intake, since lambs suckled their mothers until slaughter.

Alfalfa is the first-ranked forage crop in Spain, accounting for 23% of total forage land area and for 67% of the irrigated forage land area (MARM, 2009). Alfalfa swards are mainly located in the Ebro Valley region, being part of the traditional crop rotation of this area. This perennial crop is mainly intended for dehydration industry to produce forage with high nutritive value (16-22% crude protein), but it might be directly grazed by sheep during the vegetative season (Ramon *et al.*, 1989; Joy *et al.*, 2007).

The increase of dietary forage level triggers greater gastrointestinal digesta mass in heavy lambs (Sun *et al.*, 1994), but, to our knowledge, no study has approached this issue in light lambs. In this experiment, we hypothesised that lambs suckling and grazing high quality forage until slaughter may fill their digestive tracts with more digesta than weaned concentrate-fed lambs.

II – Material and methods

1. Experimental design

The study was conducted between summer and autumn 2008 at the facilities of the CITA Research Institute at Zaragoza (41º 42' N, 0º 49' W, 216 m a.s.l.), which is located in the Ebro Valley (North-eastern Spain). The meteorological conditions during the experiment (15th July to 5th November) were: mean maximum and minimum daily air temperatures of 26 and 12ºC and a precipitation of 119 mm.

All procedures were conducted according to the guidelines of Council Directive 86/609/EEC (European Communities, 1986) on the protection of animals used for experimental and other scientific purposes.

Thirty-two single Rasa Aragonesa lambs (mean±sd, birth date 20 July±8.0 days) were maintained with their dams (3.8±1.3 years of age, 53.3±7.3 kg BW) indoors during two weeks after birth to assure maternal bonding. Thereafter, mother-young pairs were assigned to one of four treatments in a 2 x 2 factorial design. The factors were the inclusion of forage in the diet of lambs (alfalfa grazing *vs* concentrate-fed indoors) and milk supply during the raising period (weaning at a target BW of 13 kg *vs* suckling until slaughter). The target slaughter BW was 22-24 kg. Lamb gender, ewe parity and body-weight of ewes and lambs were taken into account to balance groups.

Sixteen ewe-lamb pairs were kept in indoor facilities. The dams were fed a total dry mixed ration (11.5% crude protein) *ad libitum*. The remaining sixteen ewe-lamb pairs were maintained permanently on contiguous alfalfa crops at a stocking rate of 21 ewes plus lambs/ha. Alfalfa swards (*Medicago sativa* L., var. Aragón) were sown in spring 2003 on a loam soil (Typic Xerofluvent). Grazing was organized in a 4-week rotation sequence, in which the animals returned to the first paddock 4 weeks after leaving it. The phenologic stage of alfalfa during the experimental period was mainly from vegetative to early flowering. The crop was flood irrigated once a month. Herbage mass was not limiting throughout the experiment, with weekly available biomass of 1318±380 kg dry matter (DM) (52±10 cm height) and refusal biomass of 444±238 kg DM (16±8 cm height).

All the lambs were supplemented with concentrate (19.9% crude protein) in creep feeders placed on the alfalfa swards and indoors. At the target BW of 12-13 kg, half of the lambs were weaned

and maintained in their original location. Outdoor lambs were allowed to graze alfalfa and had free access to the same concentrate than previously whereas indoor lambs were fed the concentrate and barley straw *ad libitum*.

2. Measurements

Lambs were weighed at weekly intervals from birth to slaughter, and their ADG were estimated by linear regression of BW against time. The concentrate intake by lambs was recorded at weekly intervals.

Lambs were slaughtered at the target BW of 22-24 kg in the experimental slaughterhouse of the CITA Research Institute at Zaragoza. Prior to exsanguination, lambs were stunned by lightweight captive bolt pistol. There was no fasting period.

Digestive tracts were collected immediately after slaughter and whole tract, reticulum-rumen, omasum, abomasum, small intestine, caecum and colon-rectum were separated and weighed individually. The pH of the rumen and caecum contents was recorded with a portable pH meter equipped with a Crison 507 penetrating electrode (Crison Instruments S.A., Barcelona, Spain). Each organ was emptied of contents, rinsed repeatedly with water until clean, drained of excess water and reweighed. The digestive contents of the each gastrointestinal compartment were calculated in terms of fresh matter and dry matter (DM). The empty BW was calculated as the slaughter BW minus the contents of the digestive tract. After evisceration, carcasses were weighed and the hot carcass yield was determined.

3. Statistical analysis

Data were analysed with the general linear model (GLM procedure) of SAS statistical software (SAS, 2002):

$$y_{ijkl} = \mu + \alpha_i + \beta_j + \delta_k + (\alpha\beta)_{ij} + (\alpha\delta)_{ik} + (\beta\delta)_{jk} + \varepsilon_{ijk}$$

where: y_{ijk} =dependent variable, μ = overall mean, α_i = forage inclusion effect, β_j = milk supply effect, δ_k = sex effect and ε_{ijk} = residual error.

Results are reported as least square means and their associated standard errors. Multiple comparisons among treatments were performed by the Tukey's method. The level of significance was set at 0.05. The interactions are commented in the text only when they are significant ($P<0.05$).

III – Results and discussion

1. Animal performance

There was no effect of forage inclusion and milk supply on the ADG or the age at which lambs attained the target BW (13 kg) for the differential management (weaning or suckling) (Table 1, $P>0.05$). The ADG from this point onwards was not affected by forage inclusion but it was lower in weaned than in suckling lambs ($P<0.01$). The ADG from birth to slaughter was not affected by forage inclusion or milk supply ($P>0.05$).

Male lambs were younger than females at the start of differential management (49 *vs* 56 ± 2 days old, $P<0.05$), as well as at slaughter (90 *vs* 98 ± 3 days old, $P<0.05$). The ADG from day of differential management to slaughter was greater in male than in female lambs (265 *vs* 239 ± 9 g, $P<0.05$). As expected, the ADG from birth to slaughter was greater in male than in female lambs (219 *vs* 195 ± 7 g, $P<0.05$).

The slaughter BW and empty BW were not affected by forage inclusion or weaning (P>0.05). Carcass weight was lower in alfalfa than in concentrate-fed lambs (P<0.05) and it was also lower in weaned than in suckling lambs (P<0.05). Carcass yield was affected by the interaction between forage inclusion and milk supply (P<0.05), being lower in weaned alfalfa-fed lambs than in the rest of groups (45.0 *vs* 49.7 ± 0.7%, P<0.05).

The mean concentrate intake by lambs at the end of the raising period was 13.8 kg in suckling alfalfa-fed, 27.0 kg in weaned alfalfa-fed, 30.8 kg in suckling concentrate-fed and 36.5 kg in weaned concentrate-fed lambs.

Table 1. Productive performance of light lambs as affected by forage inclusion and milk supply

	Forage inclusion (F)		Milk supply (M)		SE	*P*-value†		
	ALF	CONC	WEAN	SUCK		F	M	Sex
BW at birth, kg	4.0	3.7	3.9	3.8	0.2	0.20	0.68	0.37
ADG from birth to differential management, g	178	165	174	169	9	0.36	0.72	0.09
Age at differential management, days	51	54	51	53	2	0.25	0.52	0.04
ADG from differential management to slaughter, g	240	264	230[a]	274[b]	9	0.06	0.002	0.04
Age at slaughter, days	94	94	97	92	3	0.87	0.19	0.03
ADG birth to slaughter, g	205	209	198	216	7	0.72	0.09	0.03
BW at slaughter, kg	22.8	23.3	23.2	22.9	0.4	0.41	0.65	0.66
Empty BW, kg	19.6	20.3	19.6	20.2	0.3	0.12	0.19	0.57
Carcass weight, kg	10.7[a]	11.4[b]	10.7[a]	11.4[b]	0.2	0.02	0.02	0.88

† Second degree interactions between fixed effects did not affect (P>0.05) any variable.

Within row and effect, different letter denote statistical differences ([a,b]=P<0.05).

2. Digestive tract contents

A. Forestomach

There was an interaction between forage inclusion and milk supply on the fresh contents (liquids +solids) of reticulum-rumen compartment (Table 2, P<0.001), which were greater (P<0.05) in weaned alfalfa-fed than in suckling alfalfa-fed lambs (2174 *vs* 1385 g) but similar in concentrate-fed lambs (1749±78 g). These figures accounts for 9.43% of the BW in weaned alfalfa-fed lambs and 6.15% of the BW in suckling alfalfa-fed lambs, while it represents 7.50% of the BW in concentrate-fed lambs.

The reticulum-rumen contents did not differ (P>0.05) between alfalfa and concentrate-fed lambs on dry matter basis, but they were greater (P<0.01) in weaned than in suckling lambs. Reticulum-rumen contents accounts for 1.81% of the BW in alfalfa-fed lambs and 1.98% of the BW in concentrate-fed lambs, while it represents 2.16% of the BW in weaned lambs and 1.62% of the BW in suckling lambs. There is close relationship between reticulum-rumen contents and feed intake (Van Soest, 1994; Molina *et al.*, 2001). Hence, outdoor raised lambs may graze alfalfa to achieve a similar dry matter intake to indoor raised concentrate-fed lambs. The omasum content was not affected (P>0.05) by forage inclusion or milk supply.

B. Lower gastrointestinal tract

The abomasum fresh matter content did not differ (P>0.05) among treatments, but alfalfa-fed lambs had lower (P<0.05) dry matter content in the abomasums than concentrate-fed lambs.

Gastric emptying is inhibited by the presence of digested products (Van Soest, 1994), which might have been greater in concentrate-fed lambs. Males had greater (P<0.05) abomasum content than females (219 *vs* 158 ± 19 g fresh weight basis), but this difference was not significant (P>0.05) on dry matter basis.

Table 2. Digestive tract contents on fresh and dry matter (DM) basis in light lambs as affected by forage inclusion and milk supply

	Forage inclusion (F)		Milk supply (M)		SE	*P*-value†		
	ALF	CONC	WEAN	SUCK		F	M	F x M
Reticulum-rumen, g	1779	1749	1961	1567	78	0.78	0.001	0.001
g DM	413	461	502[a]	372[b]	27	0.21	0.002	0.27
Omasum, g	37	24	34	26	5	0.07	0.25	0.15
g DM	8	7	8	7	1	0.38	0.34	0.51
Abomasum, g††	188	189	192	184	19	0.98	0.76	0.18
g DM	19[b]	30[a]	24	25	3	0.03	0.85	0.61
Small intestine, g	475	367	431	411	51	0.15	0.77	0.09
g DM	48	43	46	45	5	0.44	0.93	0.29
Caecum, g	320	221	298	243	31	0.03	0.22	0.01
g DM	43	36	43	36	5	0.26	0.30	0.11
Colon-rectum, g	181[a]	118[b]	155	144	11	0.001	0.5	0.29
g DM	40[a]	26[b]	36	30	3	0.003	0.13	0.51
Whole digestive tract, g	2979	2667	3072	2574	113	0.06	0.005	<0.001
g DM	571	602	659[a]	514[b]	30	0.47	0.002	0.12

† F x S and M x S interactions did not affect (P>0.05) any variable.

†† There was a sex (S) effect on this parameter (P<0.05).

Within row and effect, different letter denote statistical differences ([a,b]=P<0.05).

The small intestine contents did not differ (P>0.05) among treatments. The caecum fresh matter content was greater (P<0.05) in weaned alfalfa-fed lambs than in suckling alfalfa-fed lambs and concentrate-fed lambs (408 g *vs* 231 g and 221 g, for weaned alfalfa-fed *vs* suckling alfalfa-fed and concentrate-fed, respectively). This interaction was not significant (P>0.05) when the caecum contents were expressed on dry matter basis. The colon-rectum contents were greater (P<0.01) in alfalfa than in concentrate-fed lambs both on fresh and on dry matter basis. However, they were not affected (P>0.05) by milk supply. The greater large intestine content in alfalfa-fed lambs may be due to a greater amount of undigested fibrous residue reaching this compartment, which has a major role in pushing digesta down the intestine (Van Soest, 1994).

Overall fresh matter contents in the digestive tract were greater (P<0.05) in weaned alfalfa-fed than in suckling alfalfa-fed lambs (3581 *vs* 2378 g) but they were similar in concentrate-fed lambs (2667±160 g). Nevertheless, overall dry matter contents in the digestive tract were not affected (P>0.05) by forage inclusion but were affected (P<0.01) by milk supply (Table 2). Weaned lambs developed to a greater extent their digestive tract capacity compared to suckling lambs, mainly due to their greater reticulum-rumen fill.

C. Fermentative activity

The pH of the ruminal and caecal content was affected (P<0.05) by the interaction between forage inclusion and milk supply (Fig. 1). Weaned alfalfa-fed lambs had greater (P<0.05) ruminal and caecal pH values than the rest of treatments. The rumen and caecal liquor pH in all the lambs except those from the weaned alfalfa-fed treatment were similar to that observed by Askar *et al.*

(2008) in concentrate-fed light lambs from the same breed. Rumen cellulolytic microorganisms grow optimally at pH 6.7±0.5 (Van Soest, 1994). Accordingly, weaned alfalfa-fed lambs showed the best range for optimal microbial environment in these compartments.

In conclusion, the initial hypothesis did not hold true. Weaned but not suckling lambs raised on alfalfa filled more their digestive tracts than the rest, which also involved a more buffered digestive environment. Gender did not affect almost any digestive content, but males showed higher productive performance than females. The inclusion of forage in the diet exerted lower influence than milk supply until slaughter on the digestive adaptation of light lambs.

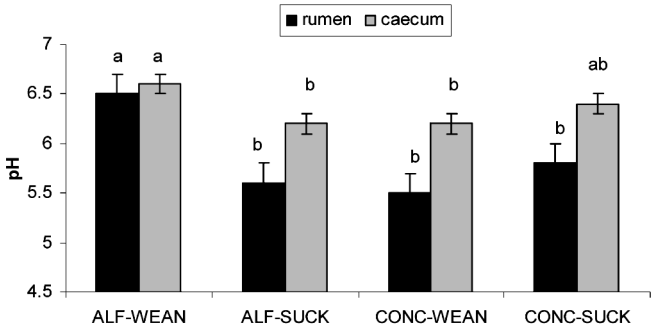

Fig. 1. Ruminal and caecal pH content in light lambs as affected by the interaction between forage inclusion and milk supply.

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References

Álvarez-Rodríguez J., Sanz A., Delfa R., Revilla R. Joy M., 2007. Performance and grazing behaviour of Churra Tensina sheep stocked under different management systems during lactation on Spanish mountain pastures. In: *Livest. Sci.,* 107, p. 152-161.

Askar A.R., Guada J.A., González J.M., de Vega A., Fondevila M., 2008. Rumen digestion and microbial protein synthesis by growing lambs fed high-concentrate diets: Effects of cereal processing and animal age. In: *Anim Feed Sci. Tech.,* 142, p. 292-305.

Joy M., Congost S., Delfa R., Álvarez-Rodríguez J., Sanz A., 2007. Diversificación de las producciones ovinas: Utilización de praderas en el cebo de corderos. In: *Informaciones Técnicas*, núm. 175. Diputación General de Desarrollo Rural, Centro de Transferencia Agroalimentaria. Gobierno de Aragón. 12 p.

Joy M., Álvarez-Rodríguez J., Revilla R., Delfa R. Ripoll G., 2008. Ewe metabolic performance and lamb carcass traits in pasture and concentrate-based production systems in Churra Tensina breed. In: *Small Rum. Res.,* 75, p. 24-35.

Large R.V., 1964. The development of the lamb with particular reference to the alimentary tract. In: *Anim. Prod.,* 6, p. 169-17.

MARM, 2009. *Anuario de estadística agroalimentaria y pesquera 2007*. Ed. Subsecretaría General Técnica, Ministerio de Medio Ambiente, Medio rural y Marino. 937 p.

Molina E., Ferret A., Caja G., Calsamiglia S., Such X., Gasa J., 2001. Comparison of voluntary food intake, apparent digestibility, digesta kinetics and digestive tract content in Manchega and Lacaune dairy sheep in late pregnancy and early and mid lactation. In: *Anim. Sci.,* 72, p. 209-221.

Ramon J.P., Uriarte J., Valderrábano J., 1989. Efecto del nivel de oferta sobre la ingestión y producción de ovejas y corderos en pastoreo de alfalfa. In: *Investigación Agraria, Producción y Sanidad Animales,* 4(1), p. 55-65.

SAS, 2002. *SAS/STAT User's Guide, Version 9.1.* SAS Institute Inc., Cary, NC, USA.

Sun W., Goetsch A.L., Forster L.A., Galloway D.L., Lewis P.K., 1994. Forage and splanchnic tissue mass in growing lambs: Effects of dietary forage levels and source on splanchnic tissue mass in growing lambs. In: *Br. J.* Nutr., 71 (2), p. 141-151.

Van Soest P.J., 1994. *Nutritional Ecology of the Rumiant, 2nd ed.* Ithaca, Ny: Cornell University Press. 474 pp.