CIHEAM
Options Méditerranéennes

Early weaning of kid goats does not compromise rumen microbial colonization and post-weaning digestive capacity

Yáñez Ruiz D.R., Martínez E., Jiménez E., Serrano R., Belanche A., Martín García A.I.

in

Ruiz R. (ed.), López-Francos A. (ed.), López Marco L. (ed.).
Innovation for sustainability in sheep and goats

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 123

2019
pages 195-200

Early weaning of kid goats does not compromise rumen microbial colonization and post-weaning digestive capacity

**D.R. Yáñez-Ruiz, E. Martínez, E. Jiménez, R. Serrano,
A. Belanche and A.I. Martín-García**

Estación Experimental del Zaidín, CSIC, Camino del Jueves s/n, 18100, Armilla, Granada, Spain

Abstract. Milk feeding in intensive dairy farming represents a significant cost, which can potentially be reduced if the animal is weaned early. However, an abrupt transition from milk to solid feed may affect animal's growth, appropriate rumen development and future digestive capacity. This experiment was conducted to assess the effect of an early weaning (EW) practice (5 weeks of life) on rumen microbial colonization and post weaning digestive ability against the normal weaning (NW) practice in diary goats farming (7-8 weeks). Twelve new-born kid goats were used and randomly allocated to one of the two experimental groups (n=6). They were provided mothers colostrum for 24 hours and then taken away and fed commercial milk replacer following the manufacturer guidelines. Alfalfa hay and starter concentrate pellets were available from week one after birth. After weaning, animals were kept together until 6 months of life. Then rumen content samples were collected and a digestibility trial was conducted. The weights of kid goats did not differ EW and NW until month six of life and both groups experienced a temporal decline in weight gain during the 7-10 days after weaning (more pronounced in EW). The fermentation pattern and microbial biomass were not different between groups. At month six of life neither the fermentation pattern nor the apparent digestibility differ between groups. Our results suggest that an early weaning strategy is possible and does not compromise the future digestive efficiency of the animal.

Keywords. Rumen development – Weaning – Microbial colonization – Goats.

Le sevrage précoce des chevreaux ne compromet pas la colonisation microbienne et le post-sevrage dans le rumen capacité digestive

Résumé. *L'allaitement dans les systèmes laitiers intensifs représente un coût important, qui peut être réduit par le sevrage précoce. Cependant, une transition brusque vers l'allaitement maternel et les aliments solides peut affecter la croissance animale, le développement approprié du rumen et la capacité digestive à l'avenir. Cette étude a été réalisée pour évaluer l'effet d'une pratique de sevrage précoce (EW, 5 semaines de vie) sur la flore microbienne du rumen et la capacité digestive après le sevrage, en fonction du temps de sevrage habituel (NW, 7-8 semaines) chez les chèvres laitières. Douze chèvres (nouveau-nés) ont été choisies et utilisées aléatoirement pour chaque groupe expérimental (n = 6). Le colostrum de leur mère a été administré à chaque chevreau pendant 24 heures, puis retiré d'eux et fourni du lait commercial reconstitué selon les indications du fabricant. Une luzerne et des granulés concentrés sont fournis librement aux chèvres dès la première semaine de la naissance. Après le sevrage, les animaux ont été maintenus ensemble jusqu'à l'âge de 6 mois, date à laquelle des échantillons de contenu ruminal ont été prélevé et un essai de digestibilité a été mené. Les poids des chevreaux ne diffèrent pas entre EW et NW jusqu'au sixième mois de vie et les deux groupes ont subi une interruption du gain de poids au cours des 7 à 10 jours suivant le sevrage (plus remarquable dans EW). Le schéma de fermentation et de la biomasse microbienne n'était pas différent entre les groupes, à l'exception des champignons, dont la concentration était plus faible chez les chevreaux EW. À six mois de vie, ni le modèle de fermentation ni la digestibilité apparente n'étaient différents entre les deux groupes. Nos résultats suggèrent qu'une stratégie de sevrage précoce est possible sans compromettre l'efficacité digestive de l'animal à l'avenir.*

Mots-clés. *Développement de rumen – Sevrage – Colonisation microbienne – Caprine*

I – Introduction

The intensification of the livestock production systems, especially in dairy production, has transformed the way newborns are reared. Normally the offspring is separated from the dam straight after birth and fed with milk replacer which may compromise development as a result of a lack of appropriate microbial gut inoculation and natural growth promoters present in whole natural milk (Soberon *et al*., 2012). This normally delays the rumen microbial development (Belanche *et al*., 2015) and the liveweight gain and increases the risk of infections by pathogens, which in many cases is addressed in commercial farms by using antimicrobials.

At birth, young ruminants have an undeveloped reticulo-rumen and they function as pre-ruminants fed on milk-based diets that are not digested in the rumen but in the abomasum (Davis and Drackley, 1998). A smooth transition from a pre-ruminant to ruminant animal, with minimal loss in growth, requires the development of the reticulo-rumen and its associated microbial population for efficient utilization of solid and forage-based diets (Heinrichs, 2005).

Development of the rumen is an important physiological challenge for young ruminants (Jiao *et al*., 2015). It entails growth and cellular differentiation of the rumen, and results in a major shift in the pattern of nutrients being delivered to the intestines and liver, and thus the peripheral tissues of the animal (Baldwin *et al*., 2004). The development of the rumen involves three distinct processes (Yáñez-Ruiz *et al*., 2015): Anatomical development (growth in rumen mass and growth of rumen papillae), physiological development (fermentation capacity and enzyme activity, and microbiological colonization. An inadequate development of the rumen will affect nutrient digestion and absorption (Baldwin *et al*., 2004). On the other hand, a complete development of the rumen facilitates digestion of feed components, which provides nutrients for the physiological requirements of the animal. This rumen development is a process that generally occurs following three phases: Preruminant (0-3 weeks); Transitional phase (3-8 weeks) and Rumination (from 8 weeks on) (Lane *et al*., 2002). However the duration of these phases can vary depending on the type of milk feeding system, availability of solid feed or weaning strategy.

Milk feeding of young ruminants in intensive dairy farming represents a significant cost, which can potentially be reduced if the animal is weaned early. However, an abrupt transition from milk to solid feed may affect animal's growth, appropriate rumen development and future digestive capacity. This experiment was conducted to assess the effect of an early weaning (EW) practice (5 weeks of life) on rumen microbial colonization and post weaning digestive ability against the normal weaning (NW) practice in diary goats farming (8 weeks).

II – Materials and methods

Twelve new-born kid goats were used and randomly allocated to one of the experimental groups (n=6): early weaning (EW) practice or normal weaning (NW). All kids were provided mothers colostrum for 24 hours and then moved to a temperature controlled experimental room (23ºC ± 1ºC; 55% HR) and fed commercial milk replacer (Nutral, SA, Madrid, Spain) following the manufacturer guidelines. Milk replacer was provided three times a day during the first 2 weeks and then twice (morning and evening). The volume offered was increased gradually after birth to a maximum of 2 litres (180 g powder/litre). Good quality alfalfa hay and starter concentrate pellets were available from week one after birth.

Weaning was conducted by reducing the concentration of milk replacer gradually during 5 days (20% less every day) to promote solid feed intake.

One group of animal was weaned at week 5 of life (Early Weaning, EW), while the other was weaned at week 8 (Normal Weaning, NW). After weaning, animals from both groups were kept together until 6 months of life, when a digestibility trial was conducted. The digestibility trial comprised total collection of faeces in metabolic cages and motorization of intake during 5 consecutive days. Animals were offered an *ad libitum* diet consisting of 50% alfalfa hay 50% commercial concentrate. Samples of faeces, diet and refusals were kept at -20ºC until analyses of DM, OM, N and NDF were performed.

Rumen contents samples were collected from all animals at 2 times: at weaning (W), one month post-weaning (PW). Rumen samples were collected via oesophageal probe following a previously described protocol (Ramos-Morales *et al*., 2014) and aliquots kept at -20ºC for VFA and molecular analyses. Animals´ weights were recorded weekly before the morning feeding.

Samples of rumen digesta were freeze-dried, genomic DNA was extracted, and DNA was used as a template to quantify the bacterial copy numbers of 16S rRNA gene by real-time PCR as described by Abecia *et al*. (2014). Data were analysed by ANOVA. Differences between means were declared when P-values were below 0.05 and considered as trends when P-values were between 0.05 and 0.10.

III – Results and discussion

There were not statistical differences in the fermentation profile between EW and NW, only tendencies for the proportion of butyric acid and the acetic/propionic ratio (Table 1). Despite the lack of differences between the experimental treatments, the fermentation profile changed clearly from pre to postweaning: acetic acid represented 79-83% of VFA at weaning, while post-weaning propionic acid became more abundant, with a 30% increase. The slight increase in concentration of total VFA from W to PW is consistent with a more developed rumen and the associated increase in solid feed intake (Heinrichs, 2005). However, the concentration at PW is still below the normal values observed in adult goats (Abecia *et al*., 2013). Nevertheless, the fact that values of total VFA concentration are not different between EW and NW groups at W suggests that the functional activity, as anaerobic fermentation, could be ready for a transition from milk to solid feed intake at 5-6 weeks of age. According to Teh *et al*. (1984), goat kids have been successfully weaned at 5 weeks if they were consuming at least 30 g/day of solid feed daily before weaning. The severity of weaning shock is then reduced. Unfortunately, the daily feed intake was not measured in the present experiment, but the lack of differences in the AGV concentration at weaning age may suggest similar solid feed intake in both treatments. An early weaning program also encourages early development of the reticulo-rumen as a result of increased solid feed consumption (Morand-Fehr, 1981). Another strategy is to wean kids by weight (Lu and Potchoiba, 1988) as discussed below.

The concentration of rumen total bacteria at weaning was around the same values observed in adult goats (Figure 1). Previous works have shown that very early in the life of the animal (first week of life) the concentration of bacteria reaches similar levels as in adult ruminants (Abecia *et al*., 2014); however, as the rumen is still growing the total biomass is very low and does not increases substantially until the second-third week of life. Despite the increase in bacterial biomass, the composition in species and functional groups that colonize the rumen will determine the ability to digest plant material, especially in artificially reared ruminants that have not direct inoculation form adult animals as new-borns raised with their mothers do (Abecia *et al*., 2017). Our results show no differences in bacterial concentration between EW and NW animals at weaning, but significantly (P<0.001) greater concentration in NW one month after weaning. This could suggest a more active rumen activity, although this is not confirmed neither by the VFA data nor the digestibility data.

Kids´ live weights during the course of the experiment (Figure 2) showed three different stages: i) same linear growth in both groups from birth until weaning, ii) then a slowdown in body weight gain at weaning with a stronger effect on EW group, and compensated growth in EW to catch up with NW at around month 4 of life. Teh *et al*.(1984) indicated that weaning at 8 weeks was optimal for goat kids. Compared with kids weaned at 8 and 10 weeks of age, weaning shock was found to be

Table 1. Effect of weaning time (Early EW, vs. Normal NW) on the fatty acids profile in then rumen of kids at weaning (W) and post-weaning (PW)

		EW	NW	SED	Pvalue
Total VFA (mM)	W	21.1	23.2	2.17	0.104
	PW	23.9	24.9	2.32	0.672
Acetate (%)	W	79.6	83,8	1.76	0.274
	PW	65.1	64.0	2.52	0.827
Propionate (%)	W	18.1	13.6	1.73	0.223
	PW	29.8	29.3	2.50	0.926
Isobutirate (%)	W	n/d	n/d	n/d	n/d
	PW	n/d	0,06	0.036	0.389
Butirate (%)	W	2.26	2.61	0.232	0.484
	PW	4.86	6.03	0.302	0.085
Isovalerate (%)	W	n/d	0.08	0.029	0.198
	PW	n/d	0.18	0.073	0.243
Valerate (%)	W	n/d	n/d	n/d	n/d
	PW	0.18	0.40	0.151	0.488
Acetate/Propionate	W	4.55	7.72	0.842	0.094
	PW	2.49	2.43	0.373	0.941

n/d, no detected.

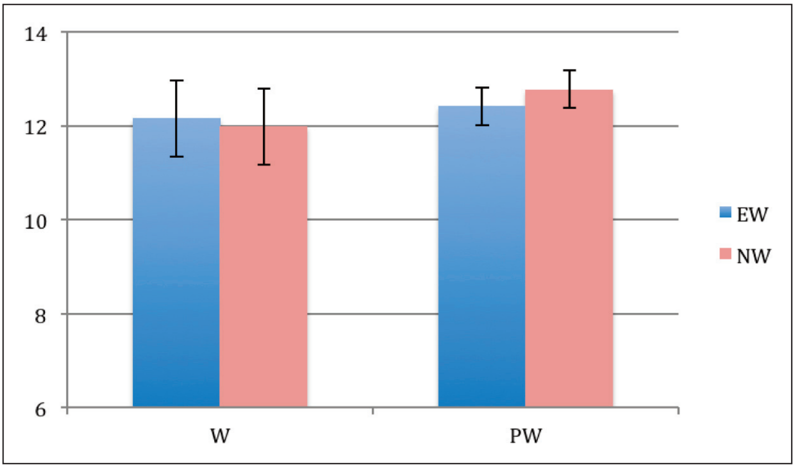

Fig. 1. Effect of weaning time (Early EW, vs. Normal NW) on bacterial abundance (log copy number 16srDNA/g fresh matter) in the rumen of kids sampled at weaning (W) and post-weaning (PW).

more severe and body weight losses were observed in those weaned at 4 and 6 weeks. Kids weaned at 4 weeks showed stunted growth for three consecutive weeks while those weaned at 6 weeks were stunted for two weeks before recovery. In our study goat kids weaned a 5 weeks showed a weaning shock with a delay in the live weight gain during two weeks, while for those weaned at 8 weeks was just one week. However, as observed in this study, subsequent compensatory growth overrode the temporary weight loss. Similar observations were noted when weaning at 4 or 8 weeks of age were compared (Owen and DePaiva, 1980). In agreement with our results similar weight gains after 5 months have been reported for goat kids weaned at 4 and 6 weeks of age (Opstvedt, 1969). What is not clear is whether the slower growth occurring in early-weaned kids affect the development of key organs (i.e. mammary gland) that potentially, can compromise milk yield in future lactations of the animal. Different studies conducted in dairy cattle have pointed that greater milk allowance (and subsequent daily growth) in calves results in higher milk yield during first and second lactations (Soberon *et al*., 2012). This remained to be determined in dairy goats.

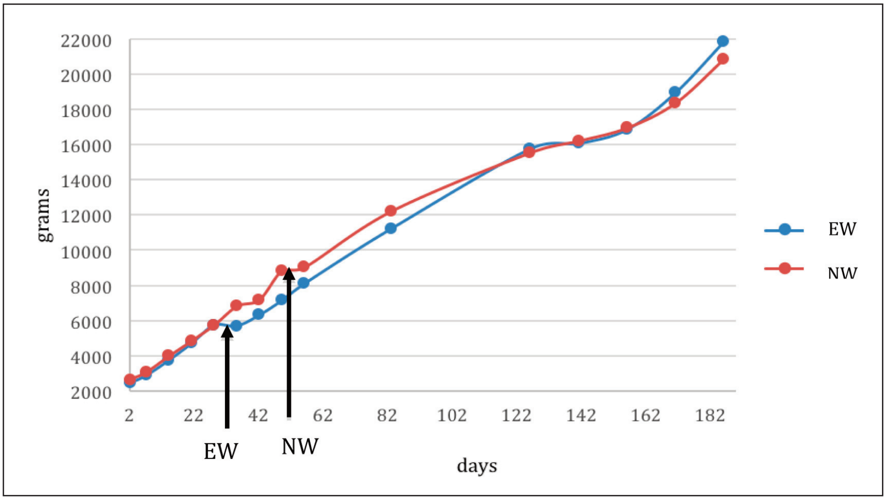

Fig. 2. Live weights of kids during the course of the trial. Arrows indicate weaning time for early weaning (EW) and normal weaning (NW) groups.

Another criteria is weaning animals by weight rather than by age. According to Lu and Potchoiba (1988), kids can be weaned when their body weights reach 2.5 times their birthweight. According to this, the animals in this study could have been weaned at 5.7 to 6.2 kg of body weight, which coincides with the values observed at 5 weeks of age. Compared to weaning by age, weaning shock seems to be less severe in kids weaned by weight (Lu and Potchoiba, 1988), although solid feed consumption is also critical for weaning by weight programs. A consumption of 30 to 50 g of concentrate has been suggested to be sufficient for early weaning (Morand-Fehr, 1981).

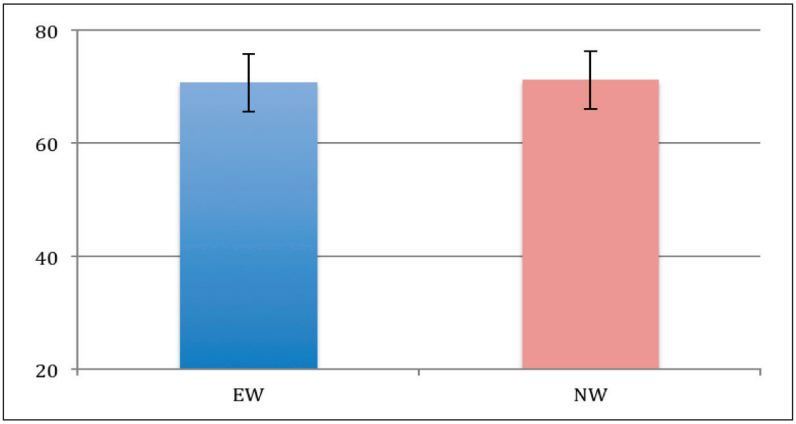

Fig. 3. Effect of weaning time (Early EW, vs. Normal NW) on dry matter apparent digestibility (g/100 g) at 6 months of age.

The total tract apparent digestibility did not differ (P<0.05) between experimental groups. This suggest that for the type of diet used in this study, the differences that could have occurred in the development of the rumen, and the rest of digestive tract, as a result of an early weaning did not compromise the digestive activity. This lack of differences could be explained by the acquisition of a similar rumen development for both experimental groups during the fattening period. Alternatively, EW lambs may have a slightly under-developed rumen function (as noted by the lower bacterial concentration), which could be compensated by a greater feed digestion in the hindgut. Further studies should be conducted to elucidate these hypotheses.

IV – Conclusions

Our results suggest that an early weaning strategy is possible and, although it temporarily slows down the growth of the animal, it does not compromise the future digestive efficiency of the animal. However, the long-term effect on animal productivity associated to the development of key tissues might need to be investigated.

References

Abecia L., Ramos-Morales E., Martínez-Fernandez G., Arco A., Martín-García A.I., Newbold C.J. and Yáñez-Ruiz D.R., 2014. Feeding management in early life influences microbial colonization and fermentation in the rumen of newborn goat kids, *Anim.Prod.Sci.,* 54, p. 1449-1454.

Abecia L., Jiménez E., Martínez-Fernández G., Martín-García I., Ramos-Morales E., Pinloche E., Denman S.E., Newbold C.J. anf Yáñez-Ruiz D.R., 2017. Natural and artificial feeding management before weaning promote different rumen microbial colonization but not differences in gene expression levels at the rumen epithelium of newborn goats, *PLoS ONE,* 12, e0182235.

Baldwin R.L., McLeod V., Klotz K.R. and Heitmann R.N., 2004. Rumen development, intestinal growth and hepatic metabolism in the pre- and postweaning ruminant, *J. Dairy Sci.,* 87, p. 55-65.

Belanche A., De la Fuente G. and Newbold C.J., 2015. Effect of progressive inoculation of fauna-free sheep with holotrich protozoa and total-fauna on rumen fermentation, microbial diversity and methane emissions, *FEMS Microbiol. Ecol.,* 91, p. 345-353.

Davis C.L. and Drackley J.K., 1998. The development, nutrition, and management of the young calf: dried whey, 1st edn. Ames: Iowa State University Press.

Heinrichs J., 2005. Rumen development in the dairy calf, *Adv. Dairy Technol.,* 17, p. 179-187.

Lane M., Baldwin R. and Jesse B., 2002. Developmental changes in ketogenic enzyme gene expression during sheep rumen development, *J. Anim. Sci.,* 80, p. 1538-1544.

Lu C.D. and Potchoiba M.J., 1988. Milk Feeding and Weaning of Goat Kids – A Review, *Anim. Feed Sci. Technol.,* 1, p. 105-112.

Morand-Fehr P., 1981. Growth. In: C. Gall (Ed.), *Goat Production*, Academic Press, London, p. 253-284.

Opstvedt J., 1969. Norwegian experiments on nutrition and milk quality in goats. In: O.R.W. Spedding (Ed.), Grassland in sheep and goat production. European Association for Animal Production, *Report* No. 2, p. 89-100.

Owen E. and DePaiva P., 1980. Artificial rearing of goat kids: effect of age at weaning and milk substitute restriction on performance to slaughter weight, *Anita. Prod.,* 30, p. 480.

Ramos-Morales E., Arco-Pérez A., Martín-García A.I., Yáñez-Ruiz D.R., Frutos P. and Hervás G., 2014. Use of stomach tubing as an alternative to rumen cannulation to study ruminal fermentation and microbiota in sheep and goats, *Anim. Feed Sci. Technol.,* 198, p. 57-66.

Soberon F., Raffrenato E., Everett R.W. and Van Amburgh M.E., 2012. Preweaning milk replacer intake and effects on long-term productivity of dairy calves, *J. Dairy Sci.,* 95, p. 783-793.

Teh T.H., Potchoiba M.J., Escobar E.N. and Lu C.D., 1984. Weaning methods of goat kids, *J. Dairy Sci.,* 67 1, p. 137.

Yañez-Ruiz D.R., Abecia L. and Newbold C.J., 2015. Manipulating rumen microbiome and fermentation through interventions during early life: a review, *Front. Microbiol.,* 6, p. 1133.