



## The Effect of Yerba Mate (*Ilex paraguariensis*) Supplementation on the Productive Performance of Dorper Ewes and Their Progeny

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**ABSTRACT:** Yerba Mate (*Ilex paraguariensis*), a tea known for its high antioxidant content, was supplemented to 30 of 60 ewes for 13 wks to assess its effect on their productive performance. A 2.5% inclusion rate of Yerba Mate (YM) in a pelleted concentrate diet decreased feed intake and live weight (LW) during the first few weeks post partum ( $p < 0.001$ ). Overall, the YM group ate less ( $2,092 \pm 78$  g/d) pellet than the control (CTRL) one ( $2,434 \pm 83$  g/d); similarly, LW was lower in the YM group compared to the CTRL one,  $64.9 \pm 1.6$  kg and  $67.3 \pm 1.4$  kg, respectively. Lambs' birth weight and growth rates were not affected. At birth, lambs' LW were similar between the Yerba Mate and control groups ( $4.2 \pm 0.5$  kg and  $4.1 \pm 0.4$  kg, respectively). At the end of the trial, Yerba Mate lambs weighed  $15.7 \pm 0.4$  kg while CTRL lambs weighed  $16.1 \pm 0.4$  kg. Average daily growth rate was similar between the two groups and ranged from  $176 \pm 19$  to  $234 \pm 24$  g/d. The inclusion of Yerba Mate in a pelleted diet increased milk fat, protein and total solids content while it decreased milk lactose content. Further work is required to investigate the mechanisms by which Yerba Mate supplementation affects feed intake and milk composition. (**Key Words:** Sheep, Growth, Yerba Mate, Tannins, Antioxidants)

### INTRODUCTION

Underfeeding pregnant sheep can induce deleterious effects on foetal and newborn lambs by adversely affecting placental size, foetal growth, deposition of foetal fat reserves for use after birth, maternal udder development and colostrum and milk production (Celi and Bush, 2010). This may be even more important in sheep when they cannot meet their energy requirements for late pregnancy especially when parturition is scheduled out-of-season, or in the instance of marginal and hill land sheep production. The adoption of intensive methods of husbandry in sheep might increase the incidence of metabolic diseases, therefore, it is imperative to pay more attention to animal health and production performances.

The use of plants containing secondary compounds in ruminant nutrition, as an alternative to other chemical compounds, has been extensively investigated in ruminant production (Wanapat et al., In Press). It is known that Yerba Mate tea (*Ilex Paraguariensis*) exerts antioxidant activity due to the presence of several compounds such as polyphenols (Heck and de Mejia, 2007). The use of

alternative feedstuff in ruminant nutrition represents a novel management tool that is green, clean, ethical (Martin and Kadokawa, 2006) and extremely easy to use. In our previous studies we were able to observe that Yerba Mate increases wool growth in lambs (Celi and Raadsma, 2009), improves milk production in dairy cows (Celi and Raadsma, 2010) and increases triglyceride levels in dairy calves (Celi and Robinson, 2010). As pregnancy, parturition and lactation are physiological stages thought to induce metabolic stress, sheep could benefit from being supplemented with Yerba Mate during the peripartum period.

Therefore, the hypothesis of this study was that the supplementation of Yerba Mate leaves in ewes' diet will improve the productive performance of both ewe and lamb. We proposed to test this hypothesis by supplementing ewes' diet with Yerba Mate during late pregnancy and early lactation, and to monitor their productive performances and those of their lambs.

### MATERIALS AND METHODS

#### Animals, location and experimental protocol

The study was conducted at the animal handling facilities of the Camden campus, Faculty of Veterinary

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Science. We used 60 Dorper ewes (initial live weight  $58.9 \pm 0.36$  kg) and their respective lambs ( $n = 73$ ). In April, the ewes were oestrous synchronised and mated so that lambing occurred within the first week of September. Oestrus was synchronised with two i.m. injections of prostaglandin  $F_{2\alpha}$  (125  $\mu$ g; Cloprostenol, Estrumate, Schering-Plough) administered 11 days apart. The ewes were ear tagged with electronic ear tags, group housed and fed a pelleted concentrate diet (Control Diet; Weston Animal Nutrition 16% Ewe and Lamb, Enfield, NSW, Australia) *ad libitum* through automatic feeders that automatically recorded individual feed intake (VFI). The nutritional composition of the pellets (88% dry matter; DM) was (as DM basis): 16% crude protein (CP), 25% neutral detergent fibre (NDF), 8.1% acid detergent fibre (ADF), 5.9% water soluble carbohydrates (WSC), 46% non fibrous carbohydrate (NFC) and 12.5 MJ/kg DM of metabolisable energy (ME). Starting at d 100 of pregnancy, ewes were gradually acclimatised to the pelleted diet over a three weeks period and then were randomly divided into two groups: one group (CTRL;  $n = 30$ ) was fed the control diet and one group (Yerba Mate;  $n = 30$ ) was fed the control diet with 2.5% Yerba Mate (dried leaves of Yerba Mate were included during the pelleting of the Weston Animal Nutrition 16% Ewe and Lamb pellet with a 2.5% inclusion rate). The nutritional composition of the Yerba Mate was: 94% DM, 16% CP, 21% NDF, 13% ADF, 1.9% WSC and 11.73 MJ/kg DM of ME and 0.1% condensed tannins. Yerba Mate also contained 9.8 mg/100 g of caffeine. The ewes received the dietary treatments starting from the last 4 wks of pregnancy (wk -4) and the subsequent 9 wks after parturition (wk 9) for a total of 13 wks. Ewes were

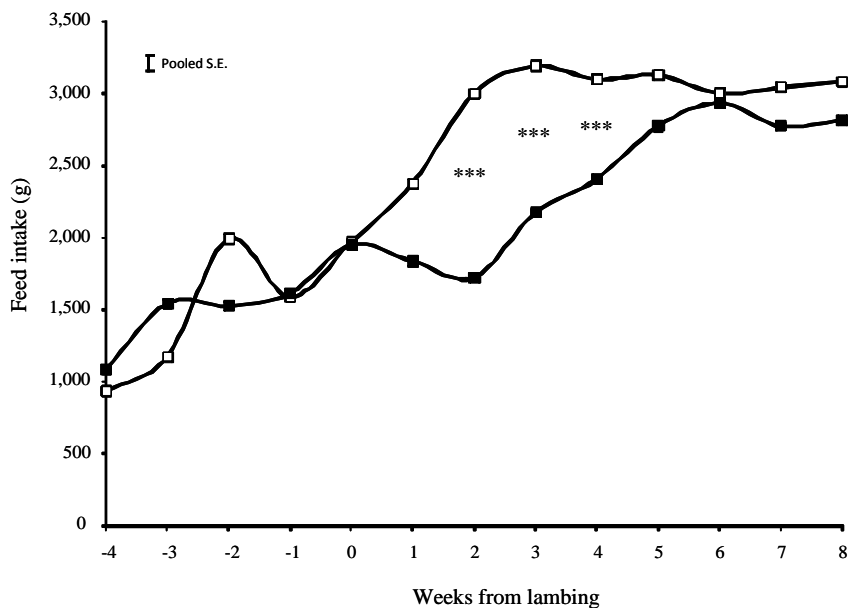
monitored for liveweight (LW) every week. Lambs were weighed with the same frequency starting from the day of birth. Milk samples were collected from all ewes at 0, day of parturition, 1, 2, 3, 4, 5, 6, 7 and 8 wks from delivery and were analysed for contents in fat, total protein and lactose by means of Milko Scan 133B (Foss-Electric, Hillerød, Denmark).

### Statistical analysis

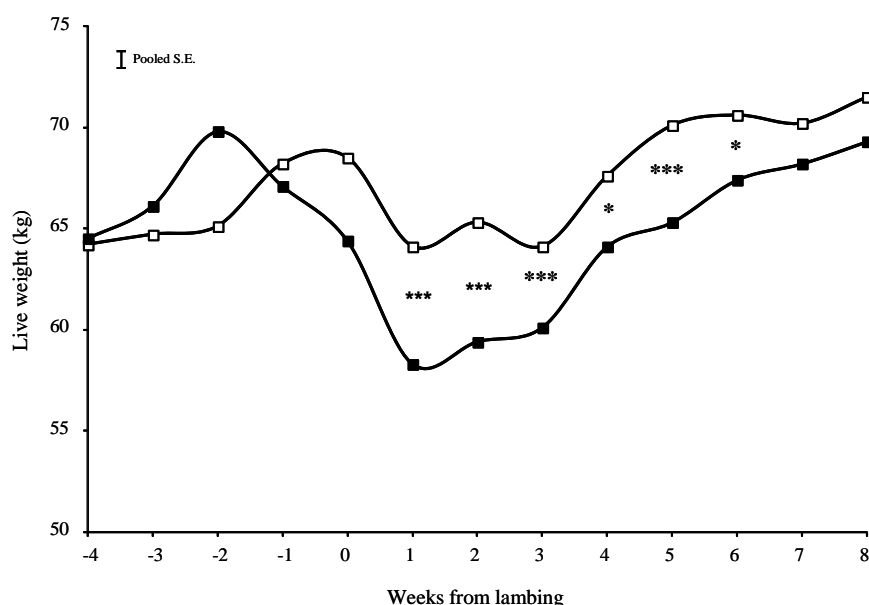
Changes in LW, VFI and milk composition were analysed by means of restricted maximum likelihood linear mixed model (REML) using the statistical analysis program GenStat (13th Edition). Analysis included between-subjects main effect of diet, within-subjects main effect of time of sampling and interaction time of sampling  $\times$  diet. The effects were considered to be significant at  $p < 0.05$ ; differences between means were tested using least significant difference. Data are reported as means  $\pm$  SEM.

## RESULTS

The number of ewes giving birth to twins for the control and the Yerba Mate groups was 10 and 9 respectively, the number of singletons was 19 and 16, and the number of empty ewes was 1 and 5, respectively. Birth type did not affect any of the traits measured in both ewes and lambs. There was a significant interaction between the effects of time of sampling  $\times$  diet ( $p < 0.001$ ) on the ewes' VFI in that Yerba Mate supplemented ewes had a significantly lower level of VFI than the control group in wks 2, 3 and 4 post partum (Figure 1). A significant effect of time ( $p < 0.001$ ) and interaction time of sampling  $\times$  diet ( $p < 0.001$ ) was also



**Figure 1.** Feed intake in Dorper ewes fed a Control Diet (Control =  $\square$ ) or supplemented with Yerba Mate (Yerba Mate =  $\blacksquare$ ). Values are expressed as means  $\pm$  SE \*\*  $p < 0.01$ .



**Figure 2.** Live weight changes in Dorper ewes fed a control diet (Control = □) or supplemented with Yerba Mate (Yerba Mate = ■). Values are expressed as means±SE \*\* p<0.01.

noted on ewes' LW. Ewes supplemented with Yerba Mate presented lower LW values from wk 1 till wk 6 after lambing compared to the control group (Figure 2). Yerba Mate supplementation had no effect on lambs' LW, however it was significantly affected by time (p<0.001) and it significantly increased over the course of the trial. At birth, lambs' LW were similar between the Yerba Mate (4.2±0.5 kg) and CTRL groups (4.1±0.4 kg). This progressively increased (p<0.001) over time but was not affected by maternal nutrition. At the end of the trial, Yerba Mate lambs weighed 15.7±0.4 kg and CTRL lambs weighed 16.1±0.4 kg. Similarly, average daily growth rate was similar between the two groups and ranged from 176±19 to 234±24 g/d.

Milk protein % was significantly affected by diet (p = 0.003) and time (p<0.001). The Yerba Mate supplemented ewes produced milk with higher protein % than control

group (Table 1). There was a significant interaction between the effects of time of sampling×diet (p<0.001) on milk fat %. Overall, milk from Yerba Mate fed ewes had higher fat content than the control group; this difference was significant during wk 2 post partum (Table 1). A significant effect of diet (p<0.001) and time (p<0.001) was noted on milk lactose %. Overall, milk from Yerba Mate fed ewes had lower lactose content than the control group (Table 1). A significant effect of diet (p<0.001), time (p<0.001) and their interaction (p = 0.009) was noted on milk solids %. Overall, milk from Yerba Mate fed ewes had higher solids content than the control group; this difference was significant during wk 2 and 8 post partum (Table 1).

## DISCUSSION

This study demonstrated that supplementation of Yerba

**Table 1.** The effect of Yerba Mate supplementation on milk composition in Dorper ewes

Item	Diet (D)	Weeks from lambing										SE	p-value		
		0	1	2	3	4	5	6	7	8	D		W	D×W	
Lactose (%)	Control	4.89	5.41	6.21	6.06	6.16	6.26	5.77	5.88	6.07	0.04	**	***		
	Yerba Mate	4.45	5.29	5.88	5.82	5.93	6.18	5.34	5.74	6.04	0.05				
Protein (%)	Control	5.59	5.53	5.54	4.87	4.44	5.65	5.02	5.35	5.39	0.14	***	***		
	Yerba Mate	7.62	6.18	5.59	4.91	4.76	6.02	5.42	5.73	5.91	0.12				
Fat (%)	Control	11.33	6.49	3.71	4.91	4.42	5.04	4.68	4.85	4.63	0.31	**	***	***	
	Yerba Mate	10.02	6.59	6.77	4.99	4.89	4.73	5.51	5.35	5.73	0.28				
Milk solids (%)	Control	22.31	18.23	16.28	16.63	16.97	17.81	16.29	16.88	16.91	0.43	***	***	**	
	Yerba Mate	22.43	18.87	19.04	16.46	17.23	17.63	17.07	17.67	18.49	0.48				

\*\* p<0.01; \*\*\* p<0.001.

For parameters where a significant effect of the Diet×Week interaction was noted (fat % and milk solids) means with different superscript letters indicate significantly difference between groups (p<0.01).

Mate to Dorper ewes had significant effects on their feed intake, live weight and milk composition, however no effect was observed on lambs' growth rate.

Yerba Mate is rich in hydrolysable tannins (Heck, 2007; Bracesco et al., 2011) and has very little condensed tannins (0.1%/kg DM). Tannins can have both adverse and beneficial effects in ruminants (Makkar et al., 2007) and the inclusion of moderate concentrations of tannins in the diet improves wool growth, weight gain, milk yield, and ovulation rate (Patra and Saxena, 2011). The inclusion in the diet of moderate levels of tannins also can stimulate feed intake (Wang et al., 1996). In the present study, a 2.5% inclusion rate of Yerba Mate in a pelleted concentrate diet decreased feed intake during the first few weeks post partum. Considering that feed intake is controlled by many factors including palatability and feed-back mechanisms, our observation indicates that Yerba Mate may depress feed intake. Indeed, post-partum VFI values were very similar to the pre-partum ones in the Yerba Mate group; however VFI values were similar to the ones observed in the control group at wk 5 post-partum. The observation that VFI was decreased in the Yerba Mate group was unexpected as in our previous study a 2.5% inclusion rate of Yerba Mate in the diet was able to increase feed intake in growing lambs (Celi and Raadsma, 2009). We could speculate that Yerba Mate might have different effects on the appetite centre according to the different physiological status (growing vs lactation) of the animal. Further work is required to investigate the precise mechanisms by which Yerba Mate influences feed intake.

Yerba Mate supplementation decreased LW in Dorper ewes from wk 1 to 7 of the trial; similar results were observed in dairy calves (Celi and Robinson, 2010) and cows (Celi and Raadsma, 2010). This observation is likely due to the concomitant decrease in VFI in the Yerba Mate group. In our previous observations, lambs that were supplemented with Yerba Mate presented a similar live weight compared to the non supplemented lambs despite a significant increase in VFI (Celi and Raadsma, 2009). It was beyond the scope of the present study to investigate the mechanism by which Yerba Mate affected LW.

Differences in mean birth LW of lambs between the Yerba Mate and CTRL groups were not significant. Studies in small ruminants have also failed to observe differences in lambs or kids birth weight, when their dams were fed with a diet designed to provide either 100 or 160% of their energy requirements (Muhlhausler et al., 2006) or 80 or 140% of their energy requirements (Celi et al., 2008a; Celi et al., 2008b). As both VFI and LW were similar between the two groups during the pre-partum period, it is likely that foetal growth was not affected by the dietary treatments. Lambs from Yerba Mate fed ewes grew with the same rate as

control lambs. This may suggest that lambs of Yerba Mate fed ewes might have removed milk more efficiently from the glands; in addition, the higher content of fat, protein and solids observed in the milk of Yerba Mate fed ewes might have sustained growth of the lambs of these ewes.

Milk yield and its quality are critical factors for the survival and growth of the newborn. Although in the present study it was not possible to measure milk yield, we were able to monitor its quality. The inclusion of Yerba Mate in a pelleted diet increased milk fat, protein and total solids % while it decreased lactose %. Lactose synthesis in the mammary gland depends on glucose and lactalbumin availability (Kuhn, 1983). It could be likely that lactalbumin availability may have been decreased by Yerba Mate supplementation, reducing lactose synthesis. The lower concentration of lactose could also be explained by a lower glucose supply to the mammary gland; most lactose synthesis in the mammary gland relies directly on blood glucose (Kuhn, 1983). Since the amount of water secreted by the mammary gland is directly related to lactose levels, and lactose synthesis is the principal driver of milk volume, it could be argued that milk yield might have been reduced by Yerba Mate supplementation. The observed increase in milk protein, fat and milk solids might also have been the consequence of a lower milk yield. Our data do not allow us to make any definitive conclusion and thus this observation needs to be confirmed in future studies.

As Yerba Mate also contains caffeine (Bracesco et al., 2003; Heck and de Mejia, 2007), we could also argue that caffeine might have contributed to the observed increase in milk fat, protein and milk solids. Caffeine has been demonstrated to increase mammary gland development, increase milk yield in mice (Sheffield, 1991) and pigs (Li and Hacker, 1995). Angiogenesis plays a key role in inflammation and repair as well as in mammary gland development. Treatments performed with aqueous extract of Yerba Mate and caffeine in the vascular membranes of chick embryos yolk sac showed angiogenic properties as well as improved embryonic growth (Strassmann et al., 2008). In caffeine treated sows, the increased amount of mammary gland parenchymal tissue might have been due to an increase in cell size and a relative increase in cell numbers, suggesting an increased secretory capacity of the mammary gland (Li and Hacker, 1995).

In conclusion, the supplementation of Yerba Mate during the peri-partum period has positive effects on milk fat, protein and total solid concentration, however it decreases milk lactose concentration. The decrease in VFI in Yerba Mate resulted in a decreased LW but importantly did not affect offspring performance. Further work is required to investigate the effect of Yerba Mate supplementation on productive performance in ruminants.

Yerba Mate can be easily imported from South America, however, further studies will have to include a complete cost-benefit analysis to assess the feasibility of Yerba Mate supplementation in the livestock industries.

#### Conflict of interest statement

None of the authors of this paper has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

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#### REFERENCES

- Bracesco, N., M. Dell, A. Rocha, S. Behtash, T. Menini, A. Gugliucci and E. Nunes. 2003. Antioxidant activity of a botanical extract preparation of *Ilex paraguariensis*: Prevention of DNA double-strand breaks in *Saccharomyces cerevisiae* and human low-density lipoprotein oxidation. *J. Altern. Complement. Med.* 9:379-387.
- Bracesco, N., A. G. Sanchez, V. Contreras, T. Menini and A. Gugliucci. 2011. Recent advances on *Ilex paraguariensis* research: Minireview. *J. Ethnopharmacol.* 136:378-384.
- Celi, P., A. Adriana Di Trana, S. Claps and P. Di Gregorio. 2008a. Effects of perinatal nutrition on metabolic and hormonal profiles of goat kids (*Capra hircus*) during their first day of life. *Asian-Aust. J. Anim. Sci.* 21:1585-1591.
- Celi, P., A. Di Trana and S. Claps. 2008b. Effects of perinatal nutrition on lactational performance, metabolic and hormonal profiles of dairy goats and respective kids. *Small Rumin. Res.* 79:129-136.
- Celi, P. and D. R. Bush. 2010. Pregnancy, lambing and survival. In: *International Sheep and Wool handbook* (Ed. D. Cottle), Nottingham University Press, pp. 223-257.
- Celi, P. and H. W. Raadsma. 2009. The effects of Yerba Mate (*Ilex paraguariensis*) supplementation on the productive performance of lambs. *Ruminant Physiology. Digestion, metabolism, and effects of nutrition on reproduction and welfare. Proceeding of the XI<sup>th</sup> International Symposium in Ruminant Physiology*, Clermont-Ferrand, France, pp. 804-805.
- Celi, P. and H. W. Raadsma. 2010. Effects of Yerba Mate (*Ilex paraguariensis*) supplementation on the productive performance of dairy cows during mid-lactation. *Anim. Prod. Sci.* 50:339-344.
- Celi, P. and A. Robinson. 2010. Effect of Yerba Mate (*Ilex paraguariensis*) supplementation on the performance of dairy calves. *Anim. Prod. Sci.* 50:376-381.
- Heck, C. I. and E. G. de Mejia. 2007. Yerba Mate tea (*Ilex paraguariensis*): A comprehensive review on chemistry, health implications, and technological considerations. *J. Food Sci.* 72: R138-R151.
- Kuhn, N. J. 1983. The biosynthesis of lactose. In: *Biochemistry of lactation* (Ed. T. M. Mepham), Amsterdam, Elsevier, pp. 159-176.
- Li, S. and R. R. Hacker. 1995. The effect of caffeine on mammary gland development and milk yield in primiparous sows. *J. Anim. Sci.* 73:534-540.
- Makkar, H. P. S., G. Francis and K. Becker. 2007. Bioactivity of phytochemicals in some lesser-known plants and their effects and potential applications in livestock and aquaculture production systems. *Animal* 1:1371-1391.
- Martin, G. B. and H. Kadokawa. 2006. "Clean, Green and Ethical" Animal Production. Case Study: Reproductive Efficiency in Small Ruminants. *J. Reprod. Dev.* 52:145-152.
- Muhlhauser, B. S., C. L. Adam, P. A. Findlay, J. A. Duffield and I. C. McMillen. 2006. Increased maternal nutrition alters development of the appetite-regulating network in the brain 10.1096/fj.05-5241fje. *FASEB Journal* 20, 1257-1259.
- Patra, A. K. and J. Saxena. 2011. Exploitation of dietary tannins to improve rumen metabolism and ruminant nutrition. *J. Sci. Food Agric.* 91:24-37.
- Sheffield, L. G. 1991. Caffeine administered during pregnancy augments subsequent lactation in mice. *J. Anim. Sci.* 69:1128-1132.
- Strassmann, B. B., A. R. Vieira, E. L. Pedrotti, H. N. F. Morais, P. F. Dias and M. Maraschin. 2008. Quantitation of methylxanthinic alkaloids and phenolic compounds in mate (*Ilex paraguariensis*) and their effects on blood vessel formation in chick embryos. *J. Agric. Food Chem.* 56:8348-8353.
- Wanapat, M., P. Kongmun, O. Pongchompu, A. Cherdthong, P. Khejornsart, R. Pilajun and S. Kaenpakdee (In Press). Effects of plants containing secondary compounds and plant oils on rumen fermentation and ecology. *Trop. Anim. Health Prod.* 1-7.
- Wang, Y., G. B. Douglas, G. C. Waghorn, T. N. Barry, A. G. Foote and R. W. Purchas. 1996. Effect of condensed tannins upon the performance of lambs grazing *Lotus corniculatus* and lucerne (*Medicago sativa*). *J. Agric. Sci.* 126:87-98.