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Milking frequency and feeding level effects on feed intake, body condition score, energy balance, and feeding behavior of late lactation dairy goats

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Abstract: This experiment divided in two successive periods (P1: milking frequency reduction period, and P2: feed adjustment period) investigated the effects of once-daily milking (ODM) and feeding level (*ad libitum* or adjusted) on nutritional status and eating pattern from dairy goat in late lactation. Dry matter intake per kg of body weight (DMIBW), body condition score (BCS), energy and nitrogen balances, and eating pattern were determined during the both periods of the study. The energy balance was increased in goats under ODM management only during P1 and was decreased in goats under feed adjustment during P2. The DMIBW was reduced when the goats were under ODM or feeding adjustment management during P2, but BCS was not modified by either ODM or feeding adjustment. The goats modified their feeding pattern during P2 under feeding adjustment, and increased their rate of intake, especially those under ODM management.

Keywords: Dairy goats, Milking frequency, Feeding level, dry matter intake, Body condition score, Energy balance, Feeding behavior

INTRODUCTION

Some studies concerning once daily milking (ODM) in dairy goats ¹⁻⁵ did not investigated this milking management effect on their nutritional status or feeding behavior in contrary to some studies conducted in dairy cows. Thus, in full lactation cows, ODM increased live weight and body condition ^{6,7}. In early

lactation cows, ODM management improved the nutritional status of the animals as they lost less live weight and body condition than those under TDM and thus improved their energy balance^{8,9}. In late lactation cows in pasture-fed, ODM milking showed a minor effects on feed intake and body condition score gain¹⁰.

In early lactation cows, ODM induced a reduction in nutritional demand for milk production and improved energy status^{11, 12} probably in accordance with the reduction observed in daily milk yield under this management. In this respect, adjustment of the quantity of feed given to dairy ruminants according to the needs for body maintenance and milk production under ODM management without energy balance or metabolic impairment could be interesting to reduce feed costs. It has been demonstrated that the goats are able to adapt their feeding behavior to the offered diet in order to limit the consequences of the supply of large quantities of carbohydrates into the rumen after feeding and better face the risks of acidosis¹³. Furthermore a method allowed the analysis of the feeding behavior of dairy goats can be used to characterize their feeding patterns when they received the same diet¹⁴. However the combined effects of ODM and feeding adjustment on eating pattern remains to be determined.

The objectives of this study were to investigate, in late lactation, the effects of ODM vs TDM managements in individually fed goats (*ad libitum* or adjusted) on, energy and nitrogen balances, body condition score, and on intake and eating pattern.

MATERIELS AND METHODS

Animals and housing: Forty pregnant Alpine and Saanen dairy goats (23 Multiparous and 17 Primiparous) in late lactation (37 ± 3 days in gestation and 239 ± 17 days in milk and 66.8 ± 12.4 kg of body weight at the start of the experiment) were housed in 2 m x 1 m individual pens with free access to water. Goats with no clinical mastitis during the preceding lactation and before the beginning of the experiment were chosen. Sixteen of these goats (3 Alpine and 13 Saanen) housed in pens equipped with weighing devices fitted under the feed trough were used to determine eating pattern throughout the day.

Experimental design, feeding and diet composition: The goats had 1 week of adaptation (**AP**) to individual pens, followed by 1 week considered as a control period (**CP**). Goats were all managed under TDM and fed *ad libitum* throughout these two weeks (preexperimental period). At the end of **CP**, the goats were allocated to ten groups of four goats according to the average dry matter afternoon feed intake (measured three times during **CP**), average milk yield (measured during 5 days in **AP** and 4 days in **CP**), and average SCC (measured on two milkings during **AP**). Among each group of 4 goats, the goats were randomly assigned to one of four experimental groups, to obtain ten goats per group, as follows: **1L** (ODM and *ad libitum* feed intake), **2L** (TDM and *ad libitum* feed intake), **1J** (ODM and adjusted feed intake) and **2J** (TDM and adjusted feed intake). The experiment was divided into two successive periods: firstly during one week (**P1**), the two milking frequencies (ODM vs TDM) were tested while the feed was given *ad libitum* and secondly during 3 weeks (**P2**), the feed was either given *ad libitum* or adjusted to milk yield and body weight (detailed below).

ODM started at the end of **CP** by suppressing the afternoon milking in twenty goats until the end of the experiment. The TDM goats were milked at 0700 h and 1530 h while the ODM goats were milked at 0700 h only.

Feed adjustment started at the end of **P1** until the end of the experiment. During **P2**, goats from **1J** and **2J** received a quantity of feed adjusted each week to their body weight (BW) and their milk yield (MY) recorded the previous week with the following formula, according to the requirements proposed in the INRA tables by Sauvant *et al.*¹⁵.

Quantity of feed (kg DM/d) = $1 + 0.120 * (BW - 60)/10 + 0.5 * MY$; for a diet with a net energy value of 0.84 UFL/kg DM.

The goats from **1L** and **2L** received their feed *ad libitum* with a weekly adjustment to ensure 10 – 15 % refusals. All the goats were fed with a total mixed ration which was offered individually twice daily in the proportion of two thirds at 1600 h and one third at 0800 h. Two mineral blocks were placed in the waiting area to milking.

Dry matter intake per kg of body weight (DMIBW) and body condition score (BCS): Animals were weighed weekly. Offered feed and refusals were individually weighed daily, which allowed the assessment of dry matter intake (DMI) using the dry matter percentage of the diet estimated weekly from water content¹⁶. Daily DMI per kilogram of body weight (DMIBW) was calculated. The BCS was measured once during CP and in the first week of **P2**.

Feeding Behavior: Feed intake was recorded by weighing devices fitted under the individual feed trough and linked to a computer. This system recorded the weight of the feed within the trough every two minutes and allowed simultaneous recording of 16 goats throughout the experiment. Data were downloaded every two days and processed on the data recorded over the 15 h following the afternoon food supply according to the method described by Desnoyers *et al.*¹⁷. A kinetic of intake is characterized by the succession of segments with different slopes corresponding to variable intake rates. A segmentation-classification method was developed to analyse these kinetics. The segmentation method calculated the number of segments of each kinetic and the position of the change points. The classification method classified all the segments of all the kinetics according to the value of their slopes in one of eight groups. For each segment, the program calculated, besides the group in which the segment was affected, the segment length (duration) and the DMIBW in this segment. Group 1 corresponded to intake rate of zero, and group 8 to the higher intake rate, with a steep slope.

Since the animals might change their eating behavior when the experimental factors change, the last four days of the P1 period and the last three days of the P2 period were considered for the eating pattern analysis.

Statistical analysis: Data were analyzed with the mixed procedure of SAS¹⁸ with animal as a random effect. The effects of milking frequency (TDM or ODM) or parity (Multiparous or Primiparous) and their interactions were tested during **P1**. The effects of milking frequency (TDM or ODM), feeding (*ad libitum* or adjusted) and parity (Multiparous or Primiparous), and their interactions were tested during **P2**. Analysis included the average values obtained for each goat during **CP** as a coverable in the model.

Only BCS data were analyzed with the GLM procedure of SAS (2000). The effects of milking frequency (TDM or ODM), feeding (*ad libitum* or adjusted) and their interactions were tested during **P2**.

RESULTS AND DISCUSSION

The body condition score (BCS) was not modified by milking treatments (**Table 1**) in disagreement with the increase reported previously in early or full lactation cows^{6,7,8}. This discrepancy could be due to the stage of lactation of the goats in our experiment or to differences between species: cow vs goat. Moreover, BCS measurement is probably not precise enough to detect a modification in a so short period of time (4 weeks in our experiment).

Table 1: Body condition score, DMIBW and energy and nitrogen balances for 3 weeks in late lactation goats under TDM or ODM management and receiving a diet either given *ad libitum* or adjusted to their body weight and milk production (adjusted feeding).

	MF ¹		SEM	FL ²		SEM	Group ³				Effects ⁴	
	TDM	ODM		L	J		2L	1L	2J	1J	MF	FL
DMIBW ⁵ (g/kg BW)	38.4	34.0	± 0.57	41.8	30.6	± 0.57	44.2 ^a	39.3 ^b	32.6 ^c	28.6 ^d	***	***
Energy balance (UFL/d) ⁶	0.31	0.32	± 0.03	0.57	0.06	± 0.03	0.53 ^a	0.60 ^a	0.08 ^b	0.04 ^b	NS	***
Nitrogen balance (PDI/d) ⁷	61.2	61.3	± 3.34	86.5	36.0	± 3.28	83.1 ^a	89.9 ^a	39.4 ^b	32.7 ^b	NS	***
Body condition score	2.98	2.98	± 0.04	3.00	2.95	± 0.04	2.98 ^a	3.02 ^a	2.97 ^a	2.98 ^a	NS	NS

NS = not significant ($P \geq 0.1$); *** $P < 0.001$.

¹MF: milking frequency, TDM: twice daily milking, ODM: once daily milking

²FL: feeding level, L: *ad libitum*, J: adjusted;

³Groups: 2L (TDM, *ad libitum*), 1L (ODM, *ad libitum*), 2J (TDM, adjusted), 1J (ODM, adjusted); within row none of the values differed ($P > 0.10$)

⁴No interaction was found between milking frequency and feeding level for all the variables

⁵DMIBW: dry matter intake per kg body weight;

⁶UFL: Energy feed unit equivalent to 1,700 kcal of net energy for lactation;

⁷PDI: Protein digested in small intestine.

Although the energy balance was reduced in the goats under feed adjustment (**Table 1**) it remained positive during the whole experiment. Furthermore, the positive and high energy balance (**Table 2**) observed in goats under ODM management during the period of milking frequency switching agrees with the improvement in energy balance reported in cows under ODM^{8,9}). In this respect, the reduction in dry matter intake per kg of body weight (DMIBW) caused by ODM or feed adjustment (Table 3) during the period of feed adjustment seemed to be induced by a decrease in the goat need for milk production under ODM management or feed adjustment management. In the same way, the energy balance even lower in goats under feed adjustment remained positive (**Table 1**).

Table 2: DMIBW and energy and nitrogen balances after the first week of milking frequency switching from TDM to ODM in late lactation goats.

	MF ¹		SEM	Effects
	TDM (n = 20)	ODM (n = 20)		MF
DMIBW ² (g/kg BW)	41.0	41.1	± 0.42	NS
Energy balance (UFL/d) ³	0.34	0.57	± 0.04	**
Nitrogen balance (PDI/d) ⁴	64.2	86.1	± 4.86	**

NS = not significant ($P \geq 0.1$); ** $P < 0.01$.

¹MF: milking frequency, TDM: twice daily milking, ODM: once daily milking

²DMIBW: dry matter intake per kg of body weight

³UFL: Energy feed unit equivalent to 1,700 kcal of net energy for lactation

⁴PDI: Protein digested in the small intestine.

In our study there was a significant interaction between goat parity and feeding level on DMIBW ($P < 0.001$). It was higher in primiparous than multiparous dairy goats when the goats were fed *ad libitum* (44.7 ± 0.70 vs 38.8 ± 0.70 g/kg BW, respectively; $P < 0.001$) but it was not different when they were managed under feed adjustment (30.3 ± 0.70 vs 30.9 ± 0.70 g/kg BW, respectively for primiparous and multiparous dairy goats; $P = 0.5$). DMIBW was higher when the primiparous (44.7 ± 0.70 vs 30.3 ± 0.70 g/kg BW) or multiparous (38.8 ± 0.70 vs 30.9 ± 0.70 g/kg BW) goats received the feed *ad libitum* compared to adjusted, respectively ($P < 0.001$).

During milking frequency reduction period (P1), ODM had no significant effect on eating pattern (**Table 3**), since the goats ate around the same quantity of feed. These results agree with those of Tucker *et al.*¹⁹ who observed no effect of milking frequency on eating duration. During feed adjustment period (P2), the goats milked once-daily ate at a higher rate their afternoon feed but the greatest difference was due to feeding level: goats ate at a higher rate when they were restricted. These results agree with those of Gorgulu *et al.*²⁰ who observed that goats increased their intake rate when they were fed-limited.

Indeed, during P2, milking frequency had a significant influence on eating pattern: the goats milked once a day ate at a very high rate since more than half of them ate in group 8 (highest eating rate) (**Table 4**). Consequently, goats milked twice a day ate a greater proportion of their diet in groups 4 to 7. Both groups ate around 10 % of their afternoon intake in the "nibbling groups" (groups 1 to 3). Feeding level had also a major influence on eating pattern: when the goats were in the adjusted groups, they ate more than 70 % of their diet in groups 8 and 7. Consequently, they ate a smaller fraction than the goats fed *ad libitum* at a medium rate (groups 5 and 6). There was also an interaction between milk frequency and feeding level,

especially for the groups 7 and 8 corresponding to the highest rates of intake.

Table 3. Percentage of intake in each group corresponding to different intake rates¹ at the end of the first week of milking frequency switching from TDM to ODM in 16 late lactation goats

	TDM (n= 8)	MF ²	ODM(n= 8)	Effect
Pintake8	9.6		15.0	NS
Pintake7	23.9		19.3	NS
Pintake6	25.5		29.2	NS
Pintake5	19.6		20.2	NS
Pintake4	6.4		5.8	NS
Pintake3	4.7		2.1	0.02
Pintake2	8.5		6.0	NS
Pintake1	1.9		2.2	NS

¹From high intake rate (group 8) to no intake (group 1)

²MF: milking frequency, TDM: twice daily milking, ODM: once daily milking

When considering the time spent in the different groups, it must be noticed that goats in adjusted groups spent a very short time eating, especially when they were milked once daily (**Figure 1**).

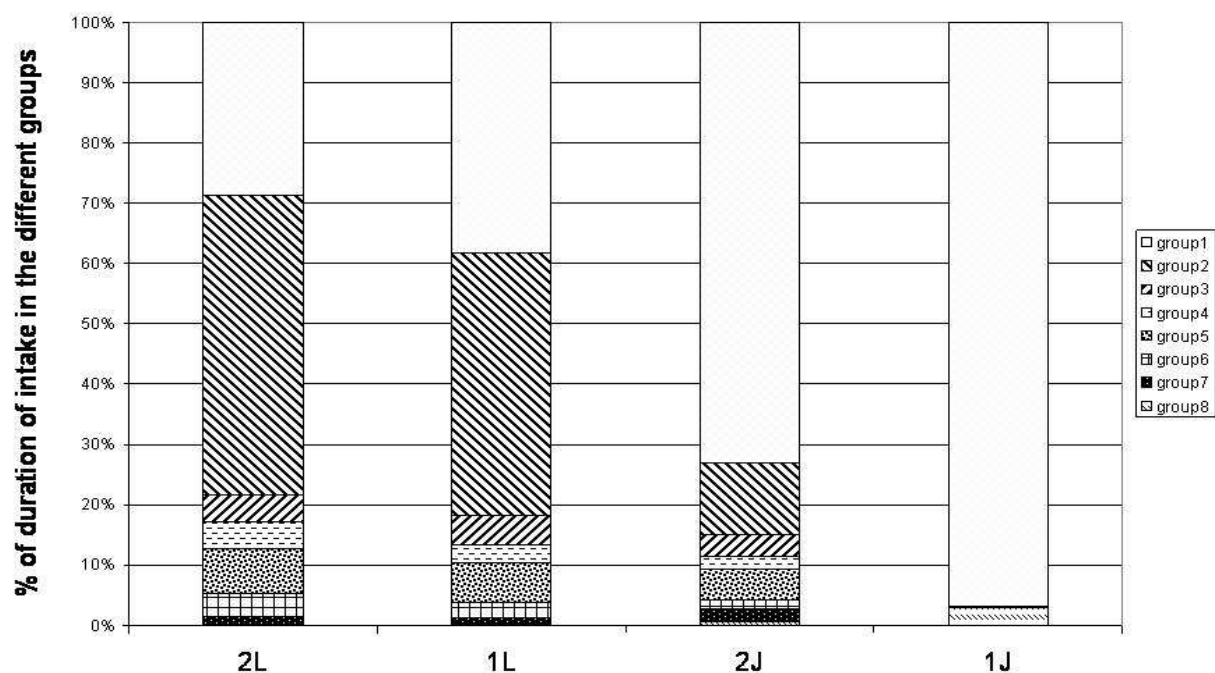


Figure 1: Duration in each group corresponding to different intake rates (group 1 = no intake; group 8 = high intake) in the last 3 days of a 3-week period in 16 late lactation goats under TDM or ODM management and receiving a diet either given ad libitum (L) or adjusted to their body weight and milk production (adjusted feeding; J)

Table 4. Percentage of intake in each group corresponding to different intake rates in the last 3 weeks of the experiment in 16 late lactation goats. The goats were under TDM or ODM management and received a diet either given *ad libitum* or adjusted to their body weight and milk production (adjusted feeding)

	MF ¹		SEM	FL ²		SEM	Group ³				Effects		
	TDM	ODM		L	J		2L	1L	2J	1J	MF	FL	MF*F
	(n = 8)	(n = 8)											
Pintake	12.4	55.8	± 3.74	15.6	52.7	± 3.74	9.2	17.8	20.8	88.7	0.001	0.001	0.001
Pintake	23.5	12.8	± 2.44	16.7	19.6	± 2.44	13.6	16.6	33.6	8.8	0.001	NS	0.001
Pintake	18.6	10.3	± 2.32	23.0	5.8	± 2.32	25.6	15.7	14.9	1.6	0.03	0.003	NS
Pintake	23.0	12.7	± 3.02	26.1	9.6	± 3.02	19.0	22.7	28.9	0.8	0.04	0.003	0.05
Pintake	7.4	2.6	± 1.60	6.0	4.1	± 1.60	9.4	6.7	4.1	0.0	0.06	NS	NS
Pintake	2.1	2.4	± 0.76	3.1	1.3	± 0.76	2.1	4.0	2.1	0.8	NS	0.03	NS
Pintake	5.6	5.9	± 1.19	12.1	0.0	± 1.19	12.7	6.3	3.7	0.2	NS	0.001	0.05
Pintake	2.0	2.9	± 0.61	2.5	2.4	± 0.61	1.8	3.8	1.5	2.7	NS	NS	NS

MF: milking frequency, TDM: twice daily milking, ODM: once daily milking

²FL: feeding level, L: *ad libitum*, J: adjusted

³Groups: 2L (TDM, *ad libitum*), 1L (ODM, *ad libitum*), 2J (TDM, adjusted), 1J (ODM, adjusted)

CONCLUSION

This study demonstrated a lack of major impairment of energy balance or nutritional status. Indeed, the dry matter intake per kg of body weight (DMIBW) has been reduced by once daily milking (ODM) after the first week of the application of this milking management. Conversely, the reduction of energy and nitrogen balances caused by ODM during the first week of its application disappear. That suggested the dairy goats' adaptation at this milking management. However, the feed adjustment management involved a modification in intake pattern and seemed to reduce energy balance although remains positive.

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