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Interim Report on the effect of once daily milking with and without calves on the nutritional composition of milk

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D4.1.1c - Interim Report on the effect of once daily milking with and without calves on the nutritional composition of milk.

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ABSTRACT

An alternative to increase the milk content in β-carotene, lutein and vitamin A and E is to reduce the cow's milk yield by a reduction of the milking frequency (Once Daily Milking – ODM -). This approach is particularly feasible in European areas where the aspiration of dairy producers towards less constraint and extended leisure time is growing. The main aim of this experiment was to (a) verify that ODM permits an increased nutritional quality of the milk (carotenoids and vitamins A and E) (b) check the consequences of leaving calves with the cows in addition to ODM during the 10 first weeks of lactation on milk yield and nutritional quality.

Thirty-six cows were used in this experiment from November 2006 to April 2007. Before calving, 3 similar groups of 12 cows were constructed according to cows' characteristics and performances. From calving, and until week 18 of lactation, the first group of cows was milked twice daily (TDM) while groups 2 and 3 were milked only once daily (ODM). In groups 1 and 2, the calves were removed at calving (as usually done in European farms) while in group 3, calves stayed with the cows until week 10. In the group ODM+calves, calves had a free access to the cows they could suckle to their convenience. During the entire experimental period, all the cows were fed a mixed ration (grass and maize silage, hay and concentrates) *ad libitum.*

At this stage, the experiment with animals is over. The milk losses due to ODM are about 36% during the first 18 weeks of lactation and average weight losses are reduced in early lactation. ODM also increases milk fat and protein content. Keeping the calves with the cows in early lactation does not permit to increase the milk yield of ODM cows when the calves are weaned. The individual milk and plasma samples for carotenoids and fat-soluble vitamins (A & E) analysis were taken on weeks 10 and 18 but the results are not yet available. All the data concerning milk nutritional composition, animal reproductive performances and behaviour will be analysed in the next 6 months period for the final report.

INTRODUCTION

Dairy products are rich in saturated fatty acids, some hydrocarbons and salt (in most cheeses) which are considered as risk factors for cardiovascular diseases in humans (Grant, 1998) if ingested in excess. Nevertheless, dairy products are also well known for providing high value proteins, vitamins (A, B group, K) and minerals such as calcium, phosphorus, magnesium, zinc and copper (Debry, 2001). Data concerning the content of micronutrients in dairy products are still incomplete in particular with respect to the factors that affect milk micronutrients like carotenoids and vitamin A and E.
Vitamin A is an essential fat-soluble vitamin that has to be provided in the diet. Dairy products represent an interesting source of vitamin A for the adult consumer and the main source for the new-born (Debry, 2001). In cows, vitamin A comes principally from the conversion of forage carotenoids into vitamin A. Carotenoids are essential pigments of plants that act as antioxidant. The β-carotene in milk comes from blood after the uptake by the mammary gland and results in yellow coloration of both body fat and milk.
Vitamin E is the principal fat-soluble antioxidant in the body. Dairy products provide only a marginal part of the vitamin E required in human nutrition (Debry, 2001) but vitamin E is important in protecting dairy compounds from oxidation. In milk, vitamin E is inversely correlated with oxidized flavours (Schingoethe *et al*., 1978).

Some recent works (Martin et al., 2005; Nozière et al., 2006) indicated that the milk concentration of β-carotene, lutein and vitamin A and E vary according the dietary supply of carotenoids and vitamin E. In comparison to maize or concentrate based diets, grass-based diets result in milk richer in carotenoids and fat soluble vitamins. When diet supplies are fixed, the factors that affect milk yield and fat content (breed, parity, physiological stage, level of intake…) also regulate carotenoid and fat soluble vitamin secretion in milk by concentration / dilution mechanisms and / or by varying the efficiency of extraction from plasma.

An alternative to increase the milk content in β-carotene, lutein and vitamin A and E is therefore to reduce the cow's milk yield (while maintaining dietary supply) by a reduction of the milking frequency. Indeed, once daily milking (ODM), in comparison to the traditional twice daily milking (TDM) is known to reduce milk yield by 20 to 50% depending on ODM duration, cow's lactation stage and parity (Rémond and Pomiès, 2005). This approach is particularly feasible in European areas where the aspiration of dairy producers towards less constraint and extended leisure time is growing and as such milk losses can be comfortably endured by the farmers. In such cases, the implementation of ODM could be an interesting solution to reduce the producers' routine labor and a feasible option for a growing number of farmers. Nevertheless, when ODM is implemented from calving, the negative impact on milk yield is higher (a decrease of 35 to 45%). In addition, the remnant losses of milk after a ODM period during early lactation is significant during the second part of lactation (15 to 25%) which reduces the acceptability of ODM for farmers. In early lactation, increasing the milking frequency is known to elevate the number of secretary cells in the udder that guarantee a good lactation. On the contrary, we can suppose that the reduction of the milking frequency in early lactation reduces the number of secretary cells in the udder and is responsible for a drastic reduction of milk yield during and after ODM. In order to counterpart these high milk losses in early lactation and after observed for cows milked once daily, we proposed to leave the calves with their mother during the first 10 weeks of the lactation so that the calves stimulate the udder and allow a higher milk yield during the end of the lactation period, when calves are removed. In addition, selling the 10 weeks old calves may provide an interesting added income for farmers.

The main aim of this experiment is therefore to (a) verify that ODM permits an increased nutritional quality of the milk (carotenoids and vitamins A and E) (b) check the consequences of leaving calves with their mother in addition to ODM during the 10 first weeks of lactation on milk yield and nutritional quality.

EXPERIMENTAL

Design, animals and diets

The experiment was carried out in the INRA experimental farm of Monts-Dore (Auvergne region, France). Thirty-six cows were used in this experiment from 12 October 2006 (first cow calving) to 5 April 2007 (all cows were at 18 weeks in milk). Before calving, 3 similar groups of 12 cows (including 4 primiparous cows) were constructed according to cows' characteristics (weight, body condition score, parity and expected calving day) and performance during the previous lactation (milk yield and composition –fat and protein content, somatic cell count). At the onset of the experimentation, the characteristics of the cows in the 3 groups are presented in Table 1. The primiparous cows were affected to the different groups according to their genetic indexes (milk yield and composition) (Table 1).
From calving, and until week 18 of lactation, the first group of cows was milked twice daily (TDM) while groups 2 and 3 were milked only once daily (ODM). In groups 1 and 2, the calves were removed at calving while in group 3, calves stayed with their mother in the free-stall housing until week 10. In the group ODM+calves, calves had a free access to the cows they could suckle to their convenience 24 hours/day. During the entire experimental period, all the cows were fed a mixed ration (grass and maize silage, hay, straw and concentrates) *ad libitum.*

Table 1. Characteristics of the cows in the different groups.

	TDM	**ODM**	**ODM+ calves**
Number of cows (primiparous)	12 (4)	12 (4)	12 (4)
Lactation rank	2.3	2.4	2.3
Expected calving date	03/11/06	04/11/06	05/11/06
Live weight before calving (kg)	647	641	635
Body condition score before calving (0-5)	2.7	2.4	2.3
Milk yield (kg/day) weeks 5-8 of previous lactation (index for primiparous)	35.8 (604)	35.6 (624)	36.2 (594)
Fat content (g/kg) weeks 5-8 of previous lactation (index for primiparous)	39.1 (-1.1)	37.0 (-1.0)	38.7 (-1.0)
Protein content (g/kg) weeks 5-8 of previous lactation (index for primiparous)	31.4 (-0.3)	31.1 (-0.2)	30.7 (-0.3)

Measurements

Milk yield was recorded individually each day of the experimental period. Milk fat, protein, lactose and somatic cell count were determined for all the individual cows at each milking of 2 days per week. Ration intake was recorded 4 days each week during the experimental period. Live weight was recorded every 2 weeks and body condition measured every month. Individual milk and plasma samples for carotenoids and fat-soluble vitamins (A & E) analysis were taken on weeks 10 and 18. In addition, forages were samples on weeks 10 and 18 for carotenoids and vitamin E analyses. Postpartum cyclicity (by progesterone measurements in milk, 3 times a week during 10 weeks), oestrus (by visual observations), artificial

insemination and pregnancy (by echography) were recorded individually to calculate reproductive performances. All the health problems and treatments of the cows and calves have been recorded during the experimental period. In addition, in order to obtain valuable information on cows and calves welfare, visual observations (direct and using cameras to film the herd before and after calf' removal) were made and calves plasma and cow milk samples were taken the day before and the days after the weaning for cortisol analyses.

Data treatment

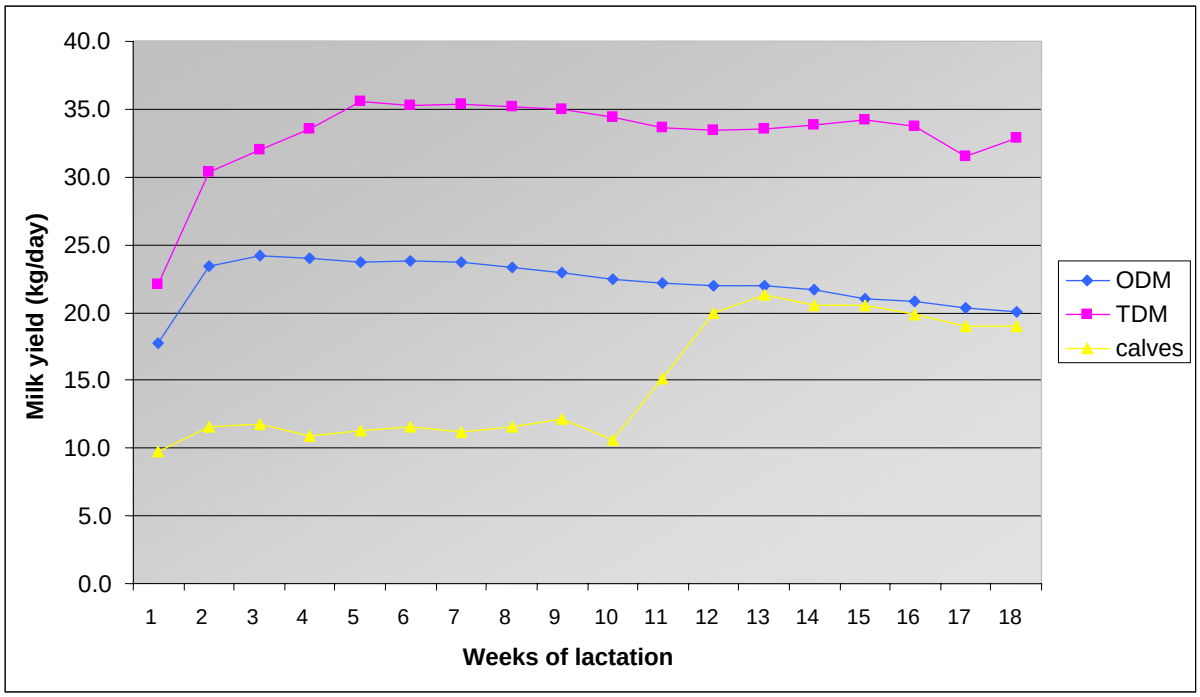
Individual average data for milk yield, fat, protein, lactose, somatic cell count and dry matter intake obtained from week 2 to week 10 (before calves removal) and from week 11 to week 18 were treated by analysis of variance with the SAS software 8.1. We introduced in the model the treatment (TDM, ODM and ODM+Calves), the parity (primiparous or multiparous) and the calving date. We also used a covariate term for milk yield, fat and protein content (genetic indexes) and for dry matter intake (calving weight). The weight and body condition score recorded on week 10 and 18 were treated using the same model with calving weight and body condition score at calving used as covariate term.

RESULTS

Milk yield

The average results are presented in Table 2.
Before the calves removal (week 1 to 10), the average milk yield of the ODM cows was reduced by 32%, in comparison to TDM cows. The lactation peak of TDM and ODM cows was observed in weeks 5 and 3 respectively (figure 1). The milk recovered in cows ODM+calves was dramatically reduced in comparison to TDM and ODM cows: the milk losses are 67 and 52% respectively. The difference between ODM and ODM+calves (11.8 kg/d) is due to the milk ingested by the calves.

Figure 1: Milk yield of the cows according to the treatment.



After the calves weaning (weeks 11 to 18), the average milk yield of the ODM cows remained 13.2 kg/d lower (-39%) than in TDM cows. The milk yielded by the ODM+calves cows was increased by 8.5 kg/d when the calves were weaned so that the milk output was similar to ODM cows. Our hypothesis that the calves suckle would stimulate the udder and allow an elevation of the number of secretary cells in the udder that could permit a higher milk yield after the calf removal was not confirmed in this experiment. This could be due to our choice of leaving a free access of the calves to their mothers 24h/d. Indeed, in some cases, the cows were suckled just before the milking so that the milk recovered was extremely low (< 3 kg/d ?). When this phenomenon happened, the calves were certainly not able to consume all the milk produced by the udder before the next milking, so that a large quantity of residual milk certainly stayed in the udder. This is probably the reason why, after the calves removal, the milk yield of the ODM+calves was not significantly higher than the ODM cows. Indeed, a high quantity of residual milk into the udder is known to retro-control negatively the milk production of the udder and limit the proliferation of the secretary cells in early lactation (Davis et al., 1999).

Considering this first result, it would have been preferable to separate the calves from their mothers during the overnight before the morning milking in order to avoid a possible suckle just before the morning milking.

Milk composition

Milk fat, protein and lactose content and SSC are shown in table 2.
As already shown in previous experiments (Rémond and Pomiès, 2005), in comparison to TDM cows, the fat and protein content of the ODM cows were increased by 5.5 and 1.7 g/kg respectively. The most important differences were observed between week 11 and week 18. This is certainly due to a concentration of milk consecutive to the reduction of the milk yield.
Before the calves weaning, the fat content was significantly lower the ODM+calves milk than in the ODM milk certainly because of an incomplete milking in this group due to the calf suckling. Indeed, the residual milk that was certainly left in the udder is richer in fat, so that the fat content of the milked milk is globally lower.

Table 2. Milk production and composition of the cows in the 3 treatments.

	TDM	ODM	ODM+ calves	RSD	Treat.	Parity	Caving date	Cov.
$Milk_{w1-10}$ (kg/d)	33.3^{a}	22.7^{b}	10.9^{c}	4.3	***	***	ns	ns
$Milk_{w11-18}$ (kg/d)	34.1^{a}	20.9^{b}	19.4^{b}	3.6	***	***	*	*
Fat_{w2-10} (g/kg)	38.1^{ab}	42.2^{a}	37.1^{b}	4.7	*	ns	ns	***
Fat_{w11-18} (g/kg)	35.3^{a}	42.3^{b}	43.0^{b}	4.5	***	ns	ns	***
$Protein_{w2-10}$ (g/kg)	31.3	32.5	31.8	1.4	ns	ns	**	*
$Protein_{w11-18}$ (g/kg)	32.3^{b}	34.6^{a}	33.5^{ab}	1.7	**	ns	***	ns
$Lactose_{w2-10}$ (g/kg)	52.9^{b}	50.4^{a}	48.7^{a}	1.7	***	***	ns	
$Lactose_{w11-18}$ (g/kg)	52.5^{b}	50.1^{a}	50.2^{a}	1.6	***	***	ns	
CCS_{w2-10} (log/mL)	4.65	5.04	4.85	0.44	ns	ns	ns	
CCS_{w11-18} (log/mL)	4.79^{b}	5.37^{a}	5.00^{ab}	0.48	*	ns	*	
$Intake_{w2-10}$ (kgDM/d)	22.6	21.6	23.1	1.6	ns	***	ns	**
$Intake_{w11-18}$ (kgDM/d)	24.6^{a}	22.5^{b}	23.7^{ab}	1.3	**	***	ns	**
$Weight_{w10}$ (kg)	651^{a}	658^{ab}	675^{b}	22	*	ns	*	***
$Weight_{w18}$ (kg)	666^{b}	688^{a}	686^{a}	22	**	*	ns	
BCS_{w10} (score0-5)	2.34^{b}	2.84^{ab}	2.90^{a}	0.49	*	+	ns	***
BCS_{w18} (score0-5)	2.07^{b}	3.09^{a}	3.26^{a}	0.30	***	ns	ns	***

***: $p<0.001$; **:$p<0.01$; *:$p<0.05$; Treat.: treatment; Cov.: covariate term.

Logically, the lactose content of milk, which governs the milk output, was significantly lower in the 2 groups of cows milked once daily (where the milk yield was lower). In addition, the SSC of the milks was not modified by the treatments during week 1 to 10 while it was increased in ODM milk after the calves weaning.

Intake, weight and body condition score

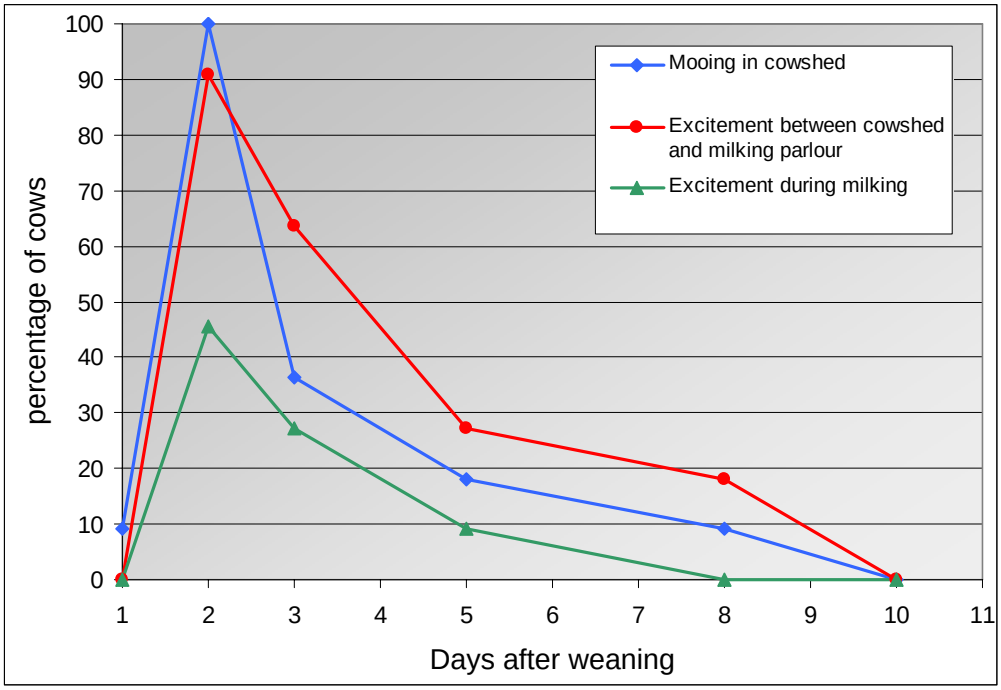
During early lactation, the total intake was not affected significantly by the treatment. In contrast, after the peak (and the weaning of calves) the total intake was significantly reduced for ODM cows in comparison of TDM cows. This is certainly related to the milk output, from which depends the intake capacity of the cows. The intake of the ODM+Calves cows was intermediary.

The cows milked once daily (ODM and ODM+calves cows) had a higher weight and body condition score than the cows milked twice daily and logically the differences were more pronounced in week 18 than in week 10. This is due to the higher energetic balance (results not presented) of the cows producing the lowest quantities of milk that permitted a faster weight recovery during the early lactation.

Cows' behavior after the calves' removal.

For the cows from the ODM+calves group, the behavior observations reveal an important increase of the mooing and excitement both during the way between the cowshed and the milking parlour and during the milking on day 2 (Figure 2). The proportion of cows concerned by those abnormal behaviors deceases as soon as day 3 to concern only 3, 2 and 1 cows on day 5 for mooing and excitement during the way to the milking parlor and during the milking respectively. On day 10, those manifestations were over for all the cows.

Figure 2: Evolution of the proportion of cows with an abnormal behavior during the days following the calves weaning.



The plasma cortisol concentrations, which reveal a stress when high, were not higher during the first days post weaning than after (results not shown).

CONCLUSIONS

The present interim report covers only the results obtained for the animal global performances. The results precise previous data concerning milk production and global composition of milk from cows milked once daily during early lactation. The milk losses due to ODM are about 36% during the first 18 weeks of lactation and average weight losses are reduced in early lactation. ODM also increase milk fat and protein content. Keeping the calves with the cows in early lactation does not permit to increase the milk yield of ODM cows when the calves are weaned.

In addition to the previous analyses, individual milk and plasma samples for carotenoids and fat-soluble vitamins (A & E) analysis were taken on weeks 10 and 18. In addition, carotenoids and vitamin E will be quantified in forages on weeks 10 and 18. All those samples are now available. They will be analysed in the next following 6 months period. Postpartum cyclicity (by progesterone measurements in milk, 3 times a week during 10 weeks), oestrus (by visual observations), artificial insemination and pregnancy (by echography) were recorded individually to calculate reproductive performances.
All the health problems and treatments of the cows and calves were recorded during the experimental period. In addition, in order to obtain valuable information on cows and calves welfare, visual observations (direct and using cameras to film the herd before and after calf' removal) were made. They will be analysed in the next 6 months period for the final report.

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