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Effect of once daily milking in dairy cows : a review of recent French experiments

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Introduction

Milking is the task which characterises the dairy producer. It accounts for about half of the duration of his routine work and it structures his daily time-table. Milking has been largely improved since hand-milking practice, but milking frequency (mostly twice daily in not-robotised milking) and hours of milking did not vary, because they constitute a good compromise between the work necessary to perform the milking and the quantity of milk harvested, determining factor of the income.

Profound evolutions intervened in the dairy activity, in particular since the dairy quota setting, in 1983 : intrusion of the citizen-consumer in the agricultural activity, liberalisation of the market of milk products, wishes of the agricultural population for less constraints … All that lead dairy producers to think about modifications in the management of their herd, taking into account its characteristics. In some situations, once daily milking (ODM) could find a place.

These reasons incited us to pursue the studies undertaken in New Zealand in the late 80s, in our conditions which are relatively different from those that prevail in this country : higher milk yield of the cows, indoor management during a part of the year, limited seasonality of the production …

Origin of the data

We used the results recorded in 11 trials performed in the last 8 years (table 1) among which one spreads over 6 years and is in progress. Results from 7 trials have been at least partly published and the results from 2 others (7 and 9) are in the process of being published. Ten trials have been carried out in the facilities of the INRA Centre of Clermont-Ferrand/Theix, and one trial (11) has been done in the experimental farm of Chambre d'agriculture du Finistère (Brittany). Objectives and experimental protocols (duration, number of cows, experimental design …) largely varied between trials, but all included a twice daily milked (TDM) group as a control. Most cows were Holstein, but some trials included also montbeliardes and tarentaise cows. In the trials managed in INRA facilities, all measures were individually done: milk yield at each milking, milk composition (fat, protein, lactose and somatic cell count [SCC]) in samples of at least each milking of one day weekly, food intake (indoor only) 4 days weekly. Frequency of other measures, and methods used are described in publications.

I – Milk production

Milk yield

Implemented during the declining phase of lactation, ODM decreases the yield of milk from the very first days, by 20-30% according to the trials. This proportion does not vary during the rest of ODM application, at least for duration of some weeks (Table 2). The loss of milk (kg/d) is higher when ODM is implemented around the peak of lactation (6^{th} week) rather than in mid-lactation (16^{th} and 27^{th} week) (7.1 kg, 4.9 kg and 3.9 kg, $P<0.01$) but, in relative value, the loss is similar (28%, 25%, 24%, respectively).

When ODM is implemented from calving, its effect establishes progressively, as previously observed by Claesson et al (1959). Milk loss (kg/d or %) is maximum around the peak of lactation. ODM has a higher effect (when applied at least 4-5 weeks), and more variable, when its application begins just after calving rather than in the declining phase of lactation (Table 2).

Once the twice daily milking (TDM) resumed, milk yield recovers rapidly, but generally not entirely. The residual milk loss is all the more lower as i/ length of ODM was shorter : loss was 2.6% (not significant) after one week of ODM, but about 10% after 7-10 weeks of ODM (Table 2); ii/ the stage of lactation where ODM was implemented was later (residual loss of 1.8 kg, 1.2 kg and 0.3 kg in weeks 9, 19 and 30 of lactation, i.e. 8.0 %, 6.7 % and 2.4 % respectively; $P<0.01$, trial 9).

When ODM was implemented for the entire lactation, the lactation curve was roughly homothetic to that of TDM management, and the yield of milk was lower by 30% (trial 3) to 47% (trial 5, primiparous cows, year 2001-02). Nevertheless the peak of lactation was reached earlier (by 1-2 weeks ; trials 3 and 5) and the lactation was shortened by 2-3 weeks (trials 3 and 11).

Many results on the decrease of the yield of milk consecutive to ODM have already been published (cf review by Davis et al, 1999). This decrease exhibits a great variability (some percents to 50%) that reflects very different experimental conditions between trials. In our conditions, losses of milk (27% on average) situate between higher milk losses (38% for Stelwagen and Knight, 1997, at the peak of lactation) and lower values (11-15% for Carruthers et al, 1989 and 1991; 15% for Lacy-Hulbert et al, 1995; 15% for Stelwagen and Lacy-Hulbert, 1996). They are similar to the losses observed by Farr et al, 1995 (26%), by Knight et Dewhurst, 1994 (23%) and by O'Brien et al, 2002 (30%). The decrease of milk yield caused by ODM is related to the accumulation of milk in alveoles, with various consequences : increased feedback action of a protein (FIL) secreted in the milk on the secretory cell activity, increased permeability of tight junctions between secretory cells, lower enzymic activity of secretory cells, increased proportion of engorged alveoles leading to quiescence and then to death (cf Davis et al, 1999; Li et al, 1999 ; Boutinaud et al, 2003). The longer the duration of ODM, and the larger the delay for the quiescent cells to revert to activity (Farr et al, 1998), and the larger also the number of secretory cells disappearing. In early lactation, ODM could also reduce multiplication of secretory cells or the differentiation that occur in this period (Knight and Wilde, 1993, in goats), particularly in primiparous animals. That would explain the higher impact of ODM in this period of lactation

The general effects of ODM on the yield of milk are influenced by various factors :

<u>Level of milk yield</u>

In a compilation of 237 data arising from the trials done in the declining phase of lactation, the loss of milk between the last week of TDM and the first week of ODM is linearly and significantly related to the milk yield of the cows : Loss of milk (kg/d) = 0.26 * previous milk yield (in TDM) (kg/d) + 0.3 ; RSD = 2.1; r2 = 0.46 ; $P < 0.01$). On the contrary, the relative loss of production (%) is unrelated to the milk yield (r2 = 0.0002). Individual variability in the decrease of milk yield (kg/d, %) is high.

The high individual variability in milk decrease explains why, compared to lower producing cows, high producing ones exhibited higher sensitivity to ODM (Holmes et al, 1992), lower sensitivity (Claesson et al, 1959) or a similar one (Knight et Dewhurst, 1994), according to the trials.

<u>Breed</u>

The effect of breed on the loss of milk induced by ODM has not been constant. Compared to the loss (%) in Holstein cows, loss in montbéliarde cows has been significantly lower in trial 6 (15% vs 23%), identical in trial 9 (26%) and tended to be higher

in trial 8 (28% vs 24%). Tarentaise cows tended to exhibit a higher residual loss than Holstein and montbéliarde cows once TDM resumed.

With breeds (Friesian and Jersey) and strains exhibiting contrasted milk composition (fat and protein content) and milk storage ability of the udder (hours worth of secretion), higher tolerance of Jersey to ODM was not clearly established (Carruthers et al, 1993; Davis et al, 1999). With our breeds that have similar milk composition, lack of difference in the sensitivity of ODM is not surprising.

Rank of lactation

In a short-term trial (3 weeks), ODM implemented from calving decreased less the milk yield of primiparous cows compared to multiparous (4.4 kg/d vs 7.8 kg/d), but the relative losses were similar (Table 3). On the other hand, in 2 other trials where ODM was implementd for 18 weeks (trial 5) or the entire lactation (trial 11), it decreased the yield of milk (kg/d) similarly in primiparous and multiparous cows (Table 3). As a consequence, the relative loss of milk (%) was higher in primiparous cows than in multiparous. Unfortunately, we do not have data on the effect of ODM on primiparous and multiparous cows when this management commences in the declining phase of lactation.

Higher sensitivity of primiparous cows to reduced milking frequency has generally been noted (Claesson et al, 1959; Woolford et al, 1985, in a trial comparing 3 milkings/2 days to TDM, Salama et al, 2003, in goats). Higher development of udder (cellular multiplication, size of cistern …) in primiparous ruminants is likely the reason of this higher sensitivity.

Repetition of ODM for several consecutive lactations

Implementation of ODM in the same cows for the first 3 entire lactations (30 cows in lactation 1, 23 cows in lactation 2 and 17 cows in lactation 3) decreased the yield of milk by a similar quantity at each lactation (11.6 kg, 10.7 kg and 11.5 kg for lactation 1, 2 and 3, respectively). The decrease of milk yield in primiparous cows (47%) was similar to that observed by Claesson et al (1959), and the decreases for lactations 2 and 3 (35% and 32%, respectively) were similar to that recorded in trials where cows were milked once daily for the first time (35% for Holmes et al, 1992; 30% for Rémond et al, 2004). From one lactation to the following one, the increase of milk yield was similar in ODM and TDM cows (11.3 kg and 11.2 kg, respectively between the 1st and the 3rd lactation). It appears, thus, that the dry period is capable to "clear" the previous modifications induced by ODM on the udder, what had been previously observed (Claesson et al, 1959; O'Brien et al, 2002).

Level of feeding

In most of our trials, ODM cows were fed in the same manner as TDM cows, and exhibited a higher energy balance (see later). In trial 1, the restriction of the quantity of concentrate offered (by 2.6 kg DM/d) so as energy balances of TDM and ODM cows should be similar, increased the loss of milk of ODM cows compared to TDM from 6.0 kg/d (25%) to 8.1 kg/d (34%). In analysis of literature, care should be taken to know in what nutritional conditions trial was conducted.

Year to year differences

During the campaigns 2001-2002, 2002-2003, 2003-2004 (30, 22 and 35 primiparous cows, respectively, managed in similar conditions; trial 5), ODM cows exhibited a lower milk yield compared to TDM cows by 47%, 43% and 40%, respectively. Expressed in kg milk, the decreases were similar (11.8 kg, 11.4 kg and 12.2 kg).

Composition of milk

Chemical composition

ODM almost systematically increased, significantly or not, the content of milk in proteins and fat, and decreased the content in lactose (Table 4). As a consequence, the decrease of the quantities of proteins and fat secreted caused by ODM were lower by 4-5 points p. 100 compared to the decrease of milk. Once TDM resumed, milk composition almost always reverted to that of the permanently TDM cows (control).

The increase of the (true) protein content (1.8 g/L, on average) caused by ODM was due to casein (1.0 g/L) and to whey proteins (0.8 g/L) (Table 5). The part of casein (56%) in the increase of total protein content is, therefore, lower than the casein/proteins ratio in the milk secreted by TDM cows (around 82%). So, ODM resulted in a systematic decrease in the content of casein in proteins, by 18 g/kg on average. The contents in IgG1 and serum albumin, which are low (<0.6 g/L) increased in a relatively large extent (30-40%).

Enzymic activities

Plasmin activity was the same for ODM and TDM cows (Table 6). In the same samples of milk, plasminogen-derived activity was 20 % higher (on average) in the ODM cows. Lipoprotein lipase (LPL) activity in the milk of ODM cows was arithmetically lower (by 28%) compared to that in TDM cows (Table 6). In ODM cows, free fatty acid content in just harvested milk was lower by 65% than the value for TDM cows, and lipolysis (measured by the release of FFA after 24H at 4° C) was lower by 56 % (Table 6)

Capacity to be processed

Milk from ODM cows (richer in proteins by 3 g/L, same pH than milk from TDM cows) exhibited a longer coagulation time (13.6 min vs 11.7 min, $P<0.05$) and a higher curd firmness (39.1 mm vs 35.6 mm respectively; $P<0.05$) (8 comparisons; measures with a Formagraph device ; trial 6). For the 8 cheeses prepared with the milk of TDM and ODM cows, after 3.5 months of ripening, none of the 16 descriptors (yield, chemical composition, colour, texture, sensory characteristics assessed by a panel) was different, except the yellow index which was higher ($P<0.10$) in cheeses made with milk from ODM cows.

Increases of the contents in fat, casein, whey proteins, IgG, serum albumin, and decrease of the content in lactose that we observed almost systematically are classical (cf Davis et al, 1999). They result from a "concentration effect", from an improvement of the energy balance of the cows (casein) and from an increased permeability of tight junctions (Stelwagen et al) which allows the leakage of lactose from milk to the blood (lactose) and the leakage of various plasma constituents from the plasma to milk (whey proteins, Na …). Increase of the protease activity, more often due to plasminogen than to plasmin, has been previously observed (Knutson et al, 1993; O'Brien et al, 2002). On the contrary, impact of ODM on LPL activity had never been measured. Azzara et Dimick (1989) observed an increase of LPL activity in the milk of goats milked hourly with ocytocin administration, that they attributed to the increased permeability of tight junctions. In the case of ODM –that also augments tight junctions permeability- the decrease of the LPL activity and of the FFA content remains to be explained.

II – Food intake and nutritional indices

Food intake

Effect of ODM on the capacity of intake of the cows can be rigorously appreciated only in trials where ODM and TDM cows receive the same diet (complete ration ad libitum, or same quantity of concentrate offered and a forage given ad libitum).

In our trials, food intake was measured only indoor, for some weeks, because of the limited duration of the ODM or the cows were turned out to grass at springtime. ODM has not (or little) changed food intake (Table 7). The duration of the measurements could have not been long enough. Indeed, it can be noticed, in trial 3 for which measurements were made for 14 weeks after calving, that food intake by ODM cows was identical to that by TDM cows for the first 6 weeks of lactation, and then became lower, the difference reaching 2 kg DM in week 14 ($P = 0.08$).

Live-weight, body condition, energy balance

Implemented from calving, ODM systematically reduced the extent of live-weight and body score decreases in the beginning of lactation (Tables 8 and 9), as well as their duration. These differences between ODM and TDM groups were all the more marked as ODM duration was longer (trial 1). Calculated energy balance of ODM cows was less negative or more positive compared to TDM cows. The difference between the live-weight, body condition and energy balance of ODM and TDM cows increased beyond the period of implementation of ODM (3 or 6 weeks in our trials) because the residual effect of ODM on milk yield was not compensated for (or not sufficiently) by a decrease of food intake. Differences in the evolution of live-weight and body condition seem stabilise when ODM is implemented for the entire lactation (trial 3). In agreement with the evolution of these indices, plasma from ODM cows had higher glucose content (+ 0.1 g/L) and lower NEFA content (-0.27 mmole/L) (measures in week 3 of lactation; trial 1).

In the trials where ODM was implemented for some weeks during the declining phase of lactation, evolutions of live-weight and body condition exhibited the same trends, but less marked, often not significant. This is probably related to the more limited impact of ODM on milk yield during this period. The lack of measures of grass intake during this period limits the possibilities of interpreting these observations.

Reproduction

In 3 trials where ODM was implemented from calving the parameters that characterise reproduction (calving-1st oestrus interval …) were generally improved (Table 12). That is likely related to the improved energy balance of the cows, and also, perhaps, to the lower milking frequency per se.

Though food intake is a determining factor of milk yield and nutritional balance, results are scarce in literature, probably because most trials were done at pasture where the measure of individual or group dry matter intake is difficult. Lack of effect, or low effect of ODM implemented for periods up to 3 months, in most of our trials agree with O'Brien et al's observations (1992). These results mean that the capacity of intake is primarily related to the capacity of milk yield of the cows, and not to their actual yield. We had previously observed the same phenomenon in a trial where milking up to the next calving (omitting the dry period) had entailed a deep diminution of the milk yield in the following lactation, without effect on the food intake (Rémond et al,). The consequence in ODM cows of the strong and rapid decrease of milk yield and of the maintain of food intake is an improved energy balance that is reflected in higher live-weight and body condition, systematically observed (Claesson et al, 1959; Holmes et al, 1992; O'Brien et al, 2002). Nevertheless, a certain decrease of food intake at medium-long term, in relation –perhaps- to the body score, and mainly at grass where cows have to harvest their food, is likely, as suggested by the slight decrease of food intake and the shorter time grazing observed by Holmes et al (1992) and Brulé et al, (2002). Improvements in criteria characterising reproduction may also reflect a better nutritional status.

III – Adaptation of cows to ODM, well being, udder health

In our trials, cows adapted rapidly to ODM, as appreciated by their behaviour. In the declining phase of lactation and at pasture (ODM and TDM groups grazed different pastures, distant from one another), first omission of milking was accompanied by vocalisations, mainly in montbéliardes cows (trial 6). On the following day morning, these cows were in a hurry to go to the milking parlour and some had milk leakage from the udder. From the second evening, their behaviour was normal. Indoor, where ODM and TDM cows were in the same free-stall barn, the sorting of the cows just before the evening milking (to prevent ODM cows from milking) never posed problem, according to the cow-handlers. Nevertheless, behaviours liable to be manifestations of discomfort have been observed. In trial 2 in early lactation, ODM cows vocalised more than TDM ones around evening milking (3.2 vocalisations/cow/h vs 0.2, before milking, and 1.6 vs 0.1 after milking). It is during the milking of the TDM cows that the ODM cows vocalised more (8.7 vocalisations/cow/h). Before the morning milking, the number of vocalisations was not significantly different (3.6 vs 1.3 vocalisations), but the number of cows whose udder was leaking was higher (9/10 vs 5/10). In 2 trials carried out in Brittany (50 cows per trial), Brulé et al (2003) observed that in very early lactation udders of ODM cows were more oedematous. Cows spend more time standing up before milking, they were more restless during milking, and cortisol content in milk was significantly higher. These behaviours decreased in later lactation, and did not appear when cows were at grass.

These last results, recorded in experimental station, contrast with what reported private farmers. In a survey in France, in 2003, in 121 private farms where ODM had been implemented for 9 weeks on average (mainly to adjust the milk yield of the herd to the milk quota allocated to the farm), all farmers said that they had been satisfied with ODM, and that the adaptation of their cows had been rapid (Guéguen and Brocard, 2003). In England, after implementing ODM, a farmer did not observe in his cows signs of discomfort (on the contrary) or desire to be milked (Hurley, personal communication). It is possible that, in experimental station, manifestations in cows liable to be interpreted as discomfort are augmented. ODM cows are housed in the same barn as TDM ones. They perceived the ritual of milking (sounds, moving of TDM cows to the milking parlour …) what is not the case either at grass, or in private farms where ODM is implemented to all cows. We have indeed observed (trial 2 ; cf before) that the number of vocalisations by ODM cows decreased by a factor 5 when the TDM cows had come back in the common loose-house barn after milking. So, vocalisations seem more manifestations of social stress rather than manifestations of pain or discomfort.

Sanitary events

Somatic cell counts

In the 4 trials where ODM was implemented from the 1st milking after calving (for 3 to 6 weeks for trials 1 and 2, for the whole lactation in the trials 3 and 5), ODM did not increased significantly SCC, at least in the first weeks of its implementation. Then, from a variable stage, (week 30 of lactation in trial 3, week 7 in trial 5), SCC of ODM cows augmented more rapidly in ODM cows than in TDM. It was significantly ($P<0.10$) higher in ODM cows for 7 from the last 15 weeks of lactation in trial 3, and significantly higher ($P<0.05$) in trial 5 from week 8 onwards. Particular reason for this was not apparent in trial 3 where only one mastitis was recorded in each group. In this trial, SCC reached 350,000/mL during the last weeks of lactation (vs 170,000 in TDM cows). The average SCC for the entire lactation (balanced for milk yield according to stage of lactation) was not statistically different (110,000/mL vs 88,000/mL in ODM and TDM cows; Table 10).

Passing from TDM to ODM induced an increase of SCC that decreased progressively in the following days. TDM resumption also entails a temporary increase of SCC. In the 5 trials where ODM was implemented in the declining phase of lactation (trial 4, 6, 7, 8, 9) it produced an arithmetical increase of SCC in each trial (32,000/mL on average ; SD = 26,000), significant in 2 trials. In these 5 trials, resumption of TDM eliminated the differences between both groups (difference of 400 cells/mL, on average).

Mastitis

In short term trials (1-10 weeks) in early lactation or in the declining phase, ODM did not augment the number of mastitis cases (Table 11), despite an increase, significant or not, of SCC.

In long term trials, situation is more contrasted : no increase of the number of mastitis in trial 3 (1 in each group; 16 cows only), but significant increase in trial 5 which had 87 primiparous cows (Table 10). In trial 11 (50 cows during the entire lactation), authors noted that mastitis required 3.5 times more interventions in ODM cows than in TDM one. In this trial, ODM caused an increase of SCC (see before), milk leakages in early lactation (indoor) that entailed dirty litters and udders. That could have favoured microbes development unfavourable for the udder health.

Other health incidents

In trials 2 and 3 in early lactation, number of cows suffering from milk fever was 7 out of 31 in TDM group and 1 out of 42 in ODM one.

Our data on SCC in milk agree with literature that generally reports an increase in SCC consecutive of ODM implementation, but not always (Lacy-Hulbert et al, 1995). This augmentation certainly partly results from a "concentration effect" since in some trials, the numbers of somatic cells secreted by ODM and TDM cows are similar (Kelly et al, 1998). Kamote et al (1994) attributed the between-trials difference in the increase of SCC consecutive of ODM to the initial SCC. Nevertheless, the influence of advancing stage of lactation that increases the difference between ODM and TDM (trials 3 and 5; Holmes et al, 1992) remains to be explained. The increases of SCC generally did not reflect a deterioration of the health status of the udder, since they were not accompanied with an increased occurrence of mastitis, in short term trials (all our short term trials; Lacy-Hulbert et al, 1995; Lynch et al 1991) as well in long term trials (trial 3; Holmes et al, 1992; Cooper; Salama et al, 2003 on goats). Nevertheless, in our long-term trials 5 and 11, the first months of which unfolded indoor, ODM significantly augmented the number of mastitis. Moreover, a British farmer reported that in his herd managed according ODM practice, the number of mastitis was less numerous but they were more difficult to cure (Hurley, personal communication). It thus appears that, according to the conditions in which ODM is implemented (duration, cowshed or pasture, level of hygiene, stage of lactation, initial SCC …) its effect on udder health could be different.

Conclusion

Our results were recorded in trials with applied objectives. They allow to better situate, in our conditions, impacts of ODM on performance (milk yield …) and animals (nutrional status, well being, udder health) in various situations of husbandry (stage of lactation particularly). The ODM management inevitably results in a noticeable decrease of the individual milk yield. This decrease can be more or less easily endured and compensated for by the farmer, according to the duration of its implementation and the characteristics of the farm (availability in pastures and places in the cowshed allowing an increase of the number of cows …).

- In the short and medium-term (some days to 2-3 months), and during the declining phase of lactation, ODM decreases the yield of milk by around 25% and appears to be safe, even if it increases SCC in a generally acceptable manner, at least in healthy herds. In early lactation, impact of ODM increases rapidly with its duration, during its implementation as well as once TDM resumed, and could provoke some discomfort in cows, and milk leakages.
- In the long-term (entire lactation), milk losses and health hazards are higher. Individual differences in the loss of milk open the possibility for selecting cows that would be less sensitive to ODM ; studies are in progress. For what concerns mastitis hazards, factors determining their occurrence have to be better identified and evaluated. Other aspects deserve also to be better studied, such as consequence on milk processing …

To progress more rapidly in many aspects referring to ODM, the detailed monitoring of farmers implementing ODM and manufacturers using milk produced in this manner should enable to better identify the questions to investigate.

References

(only the papers reporting the data of the trials presented in table 1 have been referenced)

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Table 1. List of the trials conducted by INRA-ENITA and Chambre d'Agriculture-Institut de l'Elevage used in the report for the estimation of once daily milking on milk production, nutritional indices and health.

Year of realization	Cows (prim.) breed	Main aspects of the protocol (all trials include control group milked twice daily)	Authors	Trial n°
INRA-ENITA trials				
1996-1997	50 (15) Ho	Primiparous : ODM for weeks 1-3 after calving, then TDM Multiparous : ODM for weeks 1-3 or 1-6 after calving, then TDM	Rémond et al, 1999	1
1999-2000	24 (0) Ho	ODM for weeks 1-3 after calving, then TDM, x 2 levels of conc.	Rémond et al, 2002	2
2000-2001	16 (0) Ho	ODM for the entire lactation	Rémond et al, 2004	3
2001	18 (0) Ho 6 (2) Mo	ODM for 7 weeks, at pasture ; declining phase of lactation	Rémond et al, 2002	4
2001-2007	127 (88) Ho	ODM for the entire 3 first lactations, then TDM in 4th lactation	Pomiès et al, trial in progress	5
2002	32 (9) Ho 32 (8) Mo	ODM for 7 weeks at pasture, then TDM ; declining phase of lactation	Pomiès et al, 2003	6
2003	18 (2) Ho	ODM for 2 weeks separated by 3 weeks of TDM ; declining phase	Rémond et al, 2003	7
2003-2004	54	ODM for 3 weeks or 10 weeks ; declining phase	Pomiès et al, unpubl. results	8
2003-2004	54	ODM for 3 weeks beginning at weeks 6, 16 or 27 of lactation	Pomiès et al, unpubl. results	9
2003-2004	25 (5) Ho 29 (6) Mo	TDM at normal or low level of concentrate vs ODM at the same 2 levels and at a very low level for 5 weeks, then TDM for 5 weeks	Rémond et al, unpubl. results	10
Chambre d'agriculture Finistère-EDE- Institut de l'Elevage trial				
2001-2002	50 (16) Ho	ODM for the entire lactation	Guéguen et al	11

I - MILK PRODUCTION

Table 2. Effect of the duration of the ODM implementation on the loss of milk yield during this period and once the TDM resumed (carry over effect)

Trial	ODM length	Milk in TDM group	Loss in ODM group during ODM period		Loss in ODM group once TDM resumed	
	week	kg/d	kg/d	(%)	kg/d	%
From calving						
1	3	29.8	7.2	24	1.8	5
	6	33.2	11.3	34	5.5	16
2	3	25.4	7.0	28	1.3	5
Declining phase of lactation						
7	1	32.2	8.0	25	0.8	3
4	7	19.9	5.2	26	1.7	10
6	7	19.8	4.1	21	1.4	8
8	3	24.7	7.0	28	1.8	8
	10	22.8	5.9	26	1.9	10
9	3	20.3	5.3	26	1.1	6

In each trial ODM cows were fed in the same manner (nature of feeds, quantity offered) as TDM cows. Results for Holstein cows only in trial 4.

Table 3. Effect of parity on the effect of ODM on the yield of milk (kg/d)

Trial n°	ODM length (wk)	Parity (No cows)	TDM (kg/d)	ODM effect (kg/d)	ODM effect (%)
1	3	P (15)	20.9	-4.4	-21
		M (50)	29.8	-7.2	-24
5	18	P (87)	27.4	-11.8	-43
		M ( )	33.3	-11.1	-33
11	40 ?	P (16)	20.7	-7.0	-34
		M (34)	26.2	-7.3	-28

P = primiparous cows; M = multiparous cows
In trials 1 and 11, cows from ODM and TDM groups were fed identically. In trial 5, cows from ODM group received less concentrate

Table 4. Effect of ODM on the composition of milk
(Data calculated on all trials ; the mean yield of milk was 25.0 kg and 18.1 kg for TDM and ODM group respectively)

Item (g/kg)	No groups	TDM	ODM – TDM		
			Mean	S.D.	Min/max
Fat	12	40.8	2.8	1.9	- 1.3/6.4
Protein (true)	12	31.0	1.5	1.0	0/3.3
Lactose	6	48.7	- 1.5	0.5	-0.9/-2.2

Table 5. Effect of ODM on the concentration of various proteins in milk

Item (g/L or g/kg)	TDM	ODM effect (ODM – TDM)		
		Mean	S.D.	Min/max
Proteins (true)	31.1	1.8	1.2	0.1/3.2
Caseins	25.4	1.0	1.1	- 0.6/2.2
Whey proteins	5.7	0.8	0.5	0.1/1.5
IgG1	0.52	0.15	0.15	0.01/0.38
Serum albumin	0.19	0.08	0.06	0.03/0.13
Caseins/proteins	820	- 18	7	- 7/- 27

Data from trials 1 to 6 (8 comparisons) for caseins and whey proteins, from trials 1, 2, 3 for IgG1 (5 comparisons), from trials 1 and 2 (4 comparisons) for albumin

Table 6. Effect of ODM on protease and lipoprotein lipase activity, and the content of milk in free fatty acids

Item	Trials (No compar.)	TDM	ODM	No signic compar.
Protease act.				
plasmin	2, 3, 4 (4)	4.4	4.5	0/4
plasminogen	2, 3, 4 (4)	28.9	34.6	2/4
LPL activ.	2, 3 (3)	785	567	0/3
FFA content				
0h	4, 5, 6 (3)	0.17	0.06	3/3
24h	5 (1)	0.36	0.14	1/1

Protease activity expressed as a variation of optical density. Lipoprotein lipase activity expressed as nmol/mn/mL. FFA content measured in milk just harvested (0h) and in milk after 24 h at 4°C (24h), and expressed as g of oleic acid per 100 g fat.

II - NUTRITIONAL INDICES

Table 7. Effect of ODM on feed intake (kg DM/d)

Trial no	ODM length (wk)	Period (wk)	TDM	ODM	Sign.
Same feeding to ODM and TDM cows					
	ODM from calving				
1	6	1 - 6	19.9	- 0.4	>0.10.
2	3	2 - 3	15.7	0	>0.10
3	> 40	2 – 6 7 – 14 14	19.5 21.5 22.0	- 0.2 - 1.3 - 2.0	>0.10 >0.10 0.08
11	> 40	52	16.0	-0.5	n.c.
	ODM in the declining phase				
8	3 or 10	3 or 10	6.0	- 0.5	<0.05
10	5	4 - 5	7.2	- 0.3	>0.10
Lower concentrate feeding to ODM					
		Feed			
5	18	Conc. Forage Total	5.9 13.7 19.6	- 3.9 0.6 - 3.3	 0.02 <0.01

In trials 1, 2 and 3, all cows received, during the winter period, the same total mixed ration ad libitum. In trials 8, 10 and 11, all cows received the same quantity of concentrate. Moreover, in trials 8 and 10, they received the same quantity of one forage. The second forage (of which results are reported) was fed ad libitum. In trial 5, ODM cows received less concentrate than TDM cows; forage was fed ad libitum

Table 8. Effect of ODM vs TDM on liveweight change (kg)

Trial n°	ODM length (wk)	Week of lactation	ODM	TDM	Sign.
ODM from calving					
2	3	1 3-1 16-1	 - 4.2 1.7	 - 15.1 - 34.3	 0.11 <0.01
1	6	1 6-1 11-1	 - 14.8 7.4	 - 25.7 - 25.7	 0.23 0.01
3	34	1 6-1 12-1 34-1	 - 8.5 3.0 - 28.8	 - 23.3 - 20.1 - 88.2	 0.09 0.09 < 0.01
Declining phase of lactation					
4, 6	7	1st wk 7 - 1	591 16.5	607 11.4	 0.22
8	3s, 10s				

Week after calving for trials in early lactation, week in the trial in the declining phase of lactation

Table 9. Effect of ODM vs TDM on body condition change (point of score)

Trial n°	ODM length (wk)	Week of lactation	ODM	TDM	Stat.
ODM from calving					
2	3	1 1-3 1-12	2.75 - 0.19 - 0.65	2.70 - 0.39 - 1.16	 < 0.01 < 0.01
1	3 6	11-1 11-1	- 0.8 - 0.5	- 1.3 - 1.3	> 0.10 0.10
3	34	1 4 - 1 13 - 1 39 - 1	2.78 - 0.17 -0.05 - 0.02	2.71 - 0.29 -0.086 - 1.02	 > 0.10 0.02 < 0.01
11	44	1 5 - 1 19 - 1 44 - 1	3.2 - 0.3 0.5	3.1 -0.7 - 0.5	 n.c.
Declining phase of lactation					
4	7	1 7 - 1	0.8 0.4	0.8 0.3	 > 0.10
6	7	- 2 7 – (-2)	1.6 0	1.6 0	 > 0.10

Week after calving in early lactation, week in the trial in the declining phase of lactation

III - WELL-BEING, HEALTH, REPRODUCTION

Table 10. Effect of ODM on the number of somatic cells in milk. *(Somatic cell count (x 1,000) or, for trial 11, proportion of milk samples exhibiting a SCC lower than 300,000/mL)*

Trial (No of cows)	TDM	ODM effect (SD)	Significance
Short period (1-10 wk) in declining phase			
4, 6, 7, 8, 9 (214)	91	+ 32 (26)	3 trials: n.s. 2 trials: h.s.
Long period from calving (> 18 wk)			
3 (16)	88	+ 22	n.s.
5 (88*)	65	+ 57	< 0.01
	TDM	ODM	
11 (50)	80 %	68 %	n.c.

Trial 3 : SCC differ significantly between ODM and TDM groups ($0.05 < P < 0.10$) for 7 of the last 15 weeks of the lactation, the mean reaching 400,000 cells/mL in the last weeks; in trial 5 : primiparous cows only

Table 11. Effect of ODM on mastitis frequency
(number of cows concerned/total number of cows, or number of mastitis, or number or interventions)

Trial n°	ODM length (wk)	Item (number)	ODM group	TDM group	Sign.
Short term					
4	7	cows (18)	0/9	0/9	n.c.
6	7	cows (64)	2/32	2/32	n.c.
7	1	cows (18)	0/9	0/9	n.c.
8	3 or 10	cows (54)	0/27	0/27	n.c.
9	3	cows (54)	0/27	0/27	n.c.
Long term					
3	40	Mastitis	1/9	1/7	n.c.
5	18	Cows (87)	10/37	5/50	0.04
11	40	Interventions	x 3.5*		n.c.

n.t. : not tested.
Trial 11: 3.5 times more interventions for mastitis problems in ODM group in comparison with the TDM group

Table 12. Effect of ODM on some parameters of reproduction

Trial	Item	ODM	TDM	Sign.
3	Pregnant cows at 102 d after calving /total no of cows	8/9	4/7	
5	Calving – 1st cycle (d)	24.3	28.0	n.s.
	Calving – 1st oestrus (d)	49.7	69.4	< 0.05
	Calving – successful AI (d)	105.4	129.0	0.04
	No of AI per cow	1.68	1.94	n.s.
11	Calving – 1st oestrus (d)	35	41	n.c.
	Calving – successful AI (d)	85	102	
	Success (A.I. 1 + A.I. 2)	80	68	

trial 5 : primiparous cows only (n=87)