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Original article

An attempt to omit the dry period over three consecutive lactations in dairy cows

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Summary – In 27 Holstein cows we attempted to omit the dry period over three consecutive lactations, beginning with the first lactation (experimental cows). They were compared to 18 conventionally managed cows (control cows) dried off 2 months before calving. Both groups were fed ad libitum a complete diet based on grass silage during winter. They were at pasture between May and late October. In the first lactation, only 15 experimental cows could be milked continuously until calving. Average duration of the dry period in the experimental cows was not very different in late third and fourth pregnancies compared to controls. In the second lactation, the 13 experimental cows kept for calculations (among the 15 cows milked continuously) yielded 5.6 kg/day (22%) milk less than control cows (mean for the first 36 weeks), but their milk was much richer in fat (4.0 g/kg) and in proteins (3.7 g/kg). The live weight of these cows increased in early lactation (24 kg in the first 2 months) whereas the live weight of control cows decreased (28 kg). Food intake level was unchanged. Blood composition was consistent with the better nutritional balance of continuously milked cows. For the nine experimental cows whose dry period duration was < 5 days in first lactation and > 40 days in second lactation, milk production and feed intake were not different from control cows in the third lactation.

dairy cow / dry period omission / milk secretion / nutritional status

Résumé – Tentative d'omission de la période sèche pendant trois lactations consécutives chez des vaches laitières. Chez 27 vaches Holstein, nous avons tenté de supprimer la période sèche pendant trois lactations consécutives, en commençant à la première lactation. Ces vaches ont été comparées à 18 vaches conduites conventionnellement qui ont été taries 2 mois avant le vêlage suivant. Les deux groupes ont été alimentés à volonté avec un régime complet à base d'ensilage d'herbe

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pendant l'hiver. Ils ont été conduits ensemble au pâturage entre le début du mois de mai et la fin du mois d'octobre. En fait, en première lactation, seulement 15 vaches ont pu être traites sans interruption jusqu'au deuxième vêlage. En deuxième et troisième lactations, les vaches du lot expérimental se sont presque toutes taries avant le vêlage suivant et il n'a pas été possible de réduire notablement la durée de la période sèche qui, de ce fait, a été peu différente de celle des animaux témoins. Les 13 vaches non taries retenues dans les calculs ont produit, en deuxième lactation, 5,6 kg/jour (22 %) de lait de moins que les témoins (moyenne pour les 36 premières semaines), mais leur lait a été plus riche en matières grasses (de 4,0 g/kg) et en protéines (de 3,7 g/kg). Le poids vif de ces vaches a augmenté en début de lactation (de 24 kg pendant les 2 premiers mois) tandis que celui des témoins a diminué (de 28 kg). Les quantités ingérées n'ont pas été affectées. Les différences de composition du sang entre les deux lots sont en accord avec le meilleur bilan nutritionnel des vaches non taries. Pour les neuf vaches dont la durée de la période sèche avait été inférieure à 5 j en première lactation et supérieure à 40 j en deuxième lactation, la quantité de lait sécrétée et les quantités ingérées n'ont pas été différentes de celles des animaux témoins au cours de la troisième lactation.

vache laitière / omission de la période sèche / production laitière / état nutritionnel

INTRODUCTION

Milk quota policy has made it impossible for milk producers to augment their income through increasing the volume of milk sold. As a result more attention is being paid to aspects of milk production other than milk yield; particularly to milk quality (protein content, which is increasingly priced) and to the ease of herd management (fewer health problems, more constant composition of the diet between animals and periods, higher success rate in reproduction, etc). These improvements mainly concern the beginning of lactation and they largely rely on a better (less negative) energy balance in the cows during this period.

This new context for milk production may lead to a reassessment of the dry period. Currently this is unanimously considered to have an optimal duration of 1.5 to 2 months, as this permits the highest performance over several consecutive lactations (Schaeffer and Henderson, 1972; Wood, 1985; Keown and Everett, 1986; Sorensen and Enevoldsen, 1991). Shortening or omitting the dry period improves the protein content of milk (Rémond et al, 1992a) and the nutritional balance of the cows in the early stage of the succeeding lactation (Swanson, 1965; Farries and Hoheisel, 1989). Nevertheless, omission of the dry period entails a 25 to 40% decrease of the milk yield (Klein and Woodward, 1943; Swanson, 1965; Rémond et al, 1992a), which makes its possible interest doubtful, including the possibility of extending the dry period over several consecutive lactations. So far, only Swanson (1965) with a few low-producing identical twin cows, has attempted to omit the dry period over several consecutive lactations, with partial success.

The objective of this trial was to study the possibility of omitting the dry period over three consecutive lactations and to measure its consequences on the cows' performance.

MATERIALS AND METHODS

Animals and experimental design

During three consecutive summers, 23, 12, and 10 primiparous Holstein-Friesian cows which had calved on average in late October (30 September to 26 December), at the age of 33.5 ± 3.9 months, were allocated to two groups. One group was conventionally managed and dried off 8 weeks before calving (control group); the other group had to be milked continuously over three lactations (experimental group). Both groups were established on the basis of milk yield in the first 20 weeks of lactation, age of cows,

expected calving date and live weight. More cows were allocated to the experimental group ($n = 27$) than to the control group ($n = 18$). Both groups were managed in the same manner. They were housed in a tied-stall barn during the first winter and in a free-stall barn equipped with electronic gates during the following winters. During the grazing season (between May and late October) they spent both day and night at pasture. Milkings were at 6.00 h and 17.00 h. Cows were dried off on Monday, abruptly, 2 months before the expected date of calving (control group) or after milk yield had dropped under 4 kg/day (experimental group). After the last milking, antibiotics were injected in each quarter. This injection was not given to cows of the experimental group.

Capacity of the udder to respond to exogenous growth hormone was assessed during the second lactation with the cows allocated to the trial in the first summer. Recombinant methionyl bovine somatotropin, in a slow release preparation (Sometribove, Monsanto, St-Louis, USA) was administered (500 mg) in the weeks 14 and 16 of lactation.

Feeding

During the winter period, after calving, all cows received ad libitum the same complete diet composed, on a dry matter basis, of 57% grass silage, 14% hay, 28% concentrate and 1% complement rich in minerals and vitamins. At pasture, concentrate was distributed at the rate of 1 kg per 3 kg milk above a yield declining from about 22 kg/day in spring to 12 kg/day in autumn. Cows were returned to the barn at the end of the pasture period (late October) or about 3 weeks before the expected calving date. They then received grass silage ad libitum and an increasing quantity of concentrate (2, 3 and 4 kg/day) during the 3 weeks preceding the expected calving date.

Measurements

Milk was weighed at each milking. The fat and protein contents were measured (infra-red spectrophotometry), and the somatic cells were counted (automatic counting), twice weekly. Food intake was measured 4 days a week and the live weight in the week following calving and every other week thereafter. Blood was sampled from these cows, between 8.30 and 9.30 h, from the caudal vein, on two occasions: in the first days after calving for calcium, phosphorus and magnesium analysis (data were reported by Davicco et al, 1992) and in the second week after calving for glucose, non-esterified fatty acids and 3-hydroxybutyrate analysis (enzymatic determination) in the plasma.

Data analysis

For milk production analysis, means were computed for the first 36 weeks of lactation, which were common to all cows, and for the last 8 weeks of pregnancy for the experimental group. In statistical analyses of data from lactations 2 and 3, milk yield, or protein or fat content, during the first 20 weeks of the first lactation were used as a covariate (GLM procedure, SAS, 1988). Food intake analysis was undertaken for the first 12 weeks of lactation. Two cows were withdrawn from each group at the end of the first lactation or at the beginning of the second, for health problems a priori not related to treatments. In the second lactation, data from three cows in the control group were discarded due to repeated mastitis.

RESULTS

Achievement of dry period omission

From the 27 cows of the experimental group, 15 could be milked in the first lactation until the following calving and 12 dried off despite the fact that milking was continued on these cows down to a milk yield of 3.2 (± 1.2) kg/day (table I). The 15 cows did not produce significantly more milk than cows that dried off spontaneously, during the first three consecutive periods of 11 weeks in first lactation (+ 2.2 kg; + 2.2 kg; + 1.7 kg; $P > 0.15$), but produced 3.2 kg more milk ($P = 0.03$) during the last period of 11 weeks (weeks 33 to 44). Milk persistence (milk during weeks 33 to 44 / milk during weeks 1 to 11) were 0.60 and 0.52 for both groups, respectively ($P = 0.24$). At the end of the second lactation, only 2 of the 21 pregnant cows could be milked up

Table I. Duration of lactations and dry periods.

	Lactation 1		*Lactation 2*		*Lactation 3*	
	Control	*Experim*	*Control*	*Experim*	*Control*	*Experim*
Number of cows that calved	18	27	17	27	13	21
Number of pregnant cows [1]	17	27	11	21	10	12
Number of cows according to dry period duration						
0 day		15		2		1
1 to 10 days		6		0		0
11 to 20 days		4		1		0
21 to 30 days		1		2		2
> 30 days	17	1	11	16	10	9
Duration of dry period (day)	55	7	59	54	73	61
	(17)	*(13)*	*(18)*	*(32)*	*(30)*	*(31)*
Between-calving interval (day)	384	376	368	390	403	412
	(45)	*(34)*	*(29)*	*(54)*	*(52)*	*(51)*
Milk yield in the last week of lactation (kg/day)	8.5	4.3	7.7	3.2	6.7	4.9
	(3.4)	*(1.9)*	*(3.9)*	*(1.3)*	*(2.8)*	*(2.1)*

[1] Among cows that calved and did not display sanitary problems
( ) Standard deviation

to the third calving and 16 had a dry period longer than 30 days, despite a between-calving interval lower than 13 months and the continuation of milking down to a yield of 3 kg/day. At the end of the third lactation, most cows dried off over 30 days before calving (table I).

Milk secretion

As a consequence of the large failure of being able to continue milking up to calving in second and third lactations, data analyses were focused on the effects of: 1) complete omission of dry period in the first lactation on performance in second lactation; and 2) complete or very short (< 5 days) omission of dry period in the first lactation and a nearly conventional dry period (> 40 days) in the second lactation on performance in the third lactation (study of carry-over effect).

In lactation 2 (first 36 weeks), the 13 experimental cows which had not dried off in previous lactation yielded 4.1 kg/day milk less (17%) than in lactation 1, and 5.6 kg/day less (22%) than the control group ($P < 0.01$) (table II and fig 1). Milk yielded by these 13 experimental cows was much richer in fat (4.0 g/kg) and in proteins (3.6 g/kg) than milk from the control group. Consequently, the yields of fat and proteins by experimental group decreased less (17% and 15%, respectively) than the overall milk yield. These differences in milk yield and composition in the second lactation were less accentuated in the 10 cows that dried off 1 to 20 days before the second calving: –4.3 kg/day milk, $P < 0.01$; + 0.7 g fat/kg, $P > 0.10$; + 1.5 g proteins/kg, $P < 0.05$, in comparison with control cows. The profile of the lactation curve was not modified by milking late throughout the previous pregnancy and the weekly persistence of milk yield between weeks 8 and 36 (mean of the 28 ratios: yield

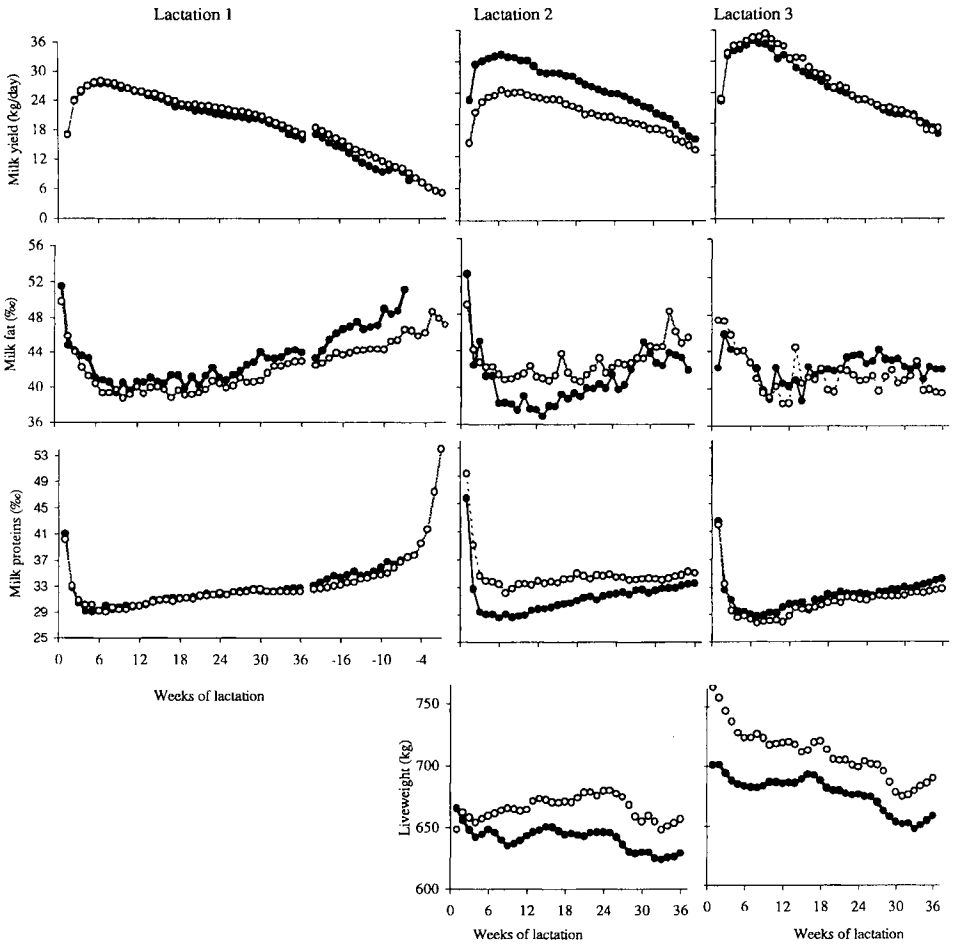

Fig 1. Evolution of milk yield, protein and fat contents and live weight in the first 36 weeks after calving (first three lactations) and the last 18 weeks before calving (lactation 1 only) (continuously milked group O; control group ●).

in week i / yield in the week i-1) was 0.975 and 0.979 respectively for control and experimental group. Consequently the difference in milk yield between both groups decreased with advancing lactation: 7.6 kg/day, 5.6 kg/day and 3.5 kg/day respectively for the consecutive 3 periods of 12 weeks after calving. In lactations 3 and 4 (data fom the latest are not reported) yields of milk, fat and proteins did not differ between treatments (table II, fig 1).

The effect of somatotropin administration was measured by the difference between the yield of milk during the 2 weeks following the first or the second injection, and during the 2 weeks preceding the first injec-

Table II. Production of milk and live weight

	Lactation 1		*Lactation 2*		*Lactation 3*	
	Control	*Experim*	*Control*	*Experim*	*Control*	*Experim*
Number of cows[1]	18	27	13	13	11	9
Milk production (first 36 weeks)[2]						
Milk (kg/day)	22.4	23.1	25.1A	19.5B	25.2	26.2
Fat (g/kg)	41.9	40.5	39.4A	43.4B	41.2	42.3
Proteins (g/kg)	31.2	31.2	31.0A	34.7B	31.6A	30.2B
Fat (g/day)	935	930	993A	820B	1064	1085
Proteins	698	716	782A	662B	790	793
Number of pregnant cows[3]	17	15	11	10	10	7
Milk production (last 8 weeks of pregnancy)						
Number of cows in milk[4]	10	15	4	5	3	2
Milk (kg)[5]	63	505	25	69	26	79
Fat (g/kg)[5]	48.7	46.1	42.1	45.9		
Proteins (g/kg)[5]	36.6	39.0	39.1	42.1		
Live weight (kg)						
Week 1 after calving[6]	621	639	668	639	711A	765B
Live weight changes						
Week 9 - week 1			–28A	24B	–20a	–42b
Week 36 - week 9			0	5	–26	–31

Means with different capital letters are different at 0.01 or 0.05 level of significance; means with different lower case letters are different at 0.10 level of significance.

[1] In the experimental group, the 13 cows used for the calculations of milk production in lactation 2 had 0 days dry period in late lactation 1; the 9 cows used in lactation 3 had 0 days (5 cows) or 1 to 4 days (4 cows) dry period in late lactation 1, and > 40 days dry period in late lactation 2 (see beginning of Results section).

[2] Adjusted means for lactations 2 and 3; statistical analysis between groups, within lactation.

[3] Among the cows used for calculations of milk production (see note 1) and for the experimental cows in lactation 1, without any day of dry period.

[4] During a part of (or all) the last 8 weeks of pregnancy, among the pregnant cows (see note 3).

[5] Individual mean for the 8 weeks, calculated on all the pregnant cows, milking or not (see note 3).

[6] Adjusted means for lactations 2 and 3, with live weight in lactation 1 as a covariate. For lactation 3, utilization of live weight in lactation 2 as a covariate gives the same results.

tion. Increases in daily milk yield (adjusted means) were 1.6 kg and 1.5 kg for control and experimental groups respectively after the first injection ($P > 0.10$), and 2.1 kg and 2.7 kg after the second injection ($P > 0.10$).

Milk yield during the last 8 weeks of the second pregnancy (end of first lactation) was 442 kg higher in the experimental group than in the control (table II). Milk yields by the experimental group during the last 8 weeks of third and fourth pregnancies were low because of the spontaneous drying off of most cows. They were, therefore, little different from the quantities yielded by control group.

Nutritional indices

Dry matter intake in the second lactation by control cows (n = 13) and experimental cows not dried off in late pregnancy (n = 13) was 19.1 kg and 19.9 kg respectively in weeks 1 to 6, and 21.4 kg and 21.2 kg in weeks 7 to 12 (adjusted means; $P > 0.10$; factors taken into account: group, year, milk yield and live weight in lactation 1). Feed intake levels were not different between the groups during the third lactation.

Live weight just after the second calving was not different ($P = 0.13$) between the experimental and control groups (table II), but it was 54 kg higher (estimated effect; $P = 0.025$) for the experimental group than for the control group after the third calving. In the beginning of second lactation, the control group lost weight whereas the experimental group gained weight ($P < 0.01$; table II). Conversely, a tendency for a higher liveweight loss in experimental group than in control group was observed in early third lactation. In lactations 2 and 3, the liveweight evolution during the declining phase of lactation (weeks 9 to 36) was not different between both groups.

Plasma concentration in glucose, measured on day 10 after calving on average, was higher in the experimental group than in the control group (67.7 mg/100 mL vs 58.2 mg/100 mL; $P < 0.05$). Conversely, concentrations in 3-hydroxybutyrate and in non-esterified fatty acids were lower ($P < 0.01$ for both metabolites) in the experimental group (0.58 mmol/L and 0.29 mmol/L, respectively) than in the control group (1.01 mmol/L and 0.75 mmol/L).

DISCUSSION

We choose to focus the data analyses in the second lactation on the only cows that did not dry off at the end of first lactation because it is known that progressive dry period reductions decrease more than proportionately milk yield during the following lactation (Klein and Woodward, 1943). Cows kept in the statistical analysis tended to be higher producers (which is taken into account in covariance analysis) but the persistence of their milk secretion was not different (see above). The estimation of the effects of the dry period omission has, therefore, probably not been biased

Implementation of the dry period omission

This trial was conducted primarily to study the possibility of omitting the dry period over several consecutive lactations. Indeed, except in the trials by Swanson (1965) and Coppock et al (1974), reductions or omissions of the dry period reported in the literature were not repeated, and the data mainly originated from commercial herds where shortening of the dry period was probably rarely sought. In our trial, incomplete omission of the dry period in primiparous cows and the fact that its duration was only slightly reduced at the end of the second lactation and third lactation (which was preceded by a dry period of nearly normal duration) showed that this management is difficult to implement, as previously observed by Swanson (1965) on low-yielding cows. These results contrasted with our previous observations in a commercial herd where all the cows (n = 37) were managed without a single day of dry period (Rémond and Bonnefoy, 1997). As discussed in that study, higher levels of milk yield (> 10 000 kg milk/cow/year) and feeding (demonstrated by all the nutritional indices measured: monthly persistency of milk yield > 95%, high level of distribution of maize silage during the entire pasture period, very high live weight gain during lactation) appear to be the most plausible reasons explaining this systematic achievement of drying off omission. In the present trial, late lactation

and late pregnancy coincided with being at pasture in late summer and early autumn. The level of feeding during this period may have been too low, despite distribution of concentrate, to support milk secretion in a period where its diminution accelerates with advancing pregnancy (Coulon et al, 1995). Moreover, the return to the barn in mid-autumn has been shown to have a deleterious effect on milk yield (Coulon et al, 1986). The difficulty in maintaining milk secretion in late pregnancy and lactation is accentuated in multiparous cows that naturally secrete less milk than primiparous cows after about 30 weeks of lactation, because of their lower persistency (Schutz et al, 1990).

Milk secretion

This trial confirmed the deep modifications in the milk secretion of cows during the lactation that follows omission of the dry period, which is different from that which occurs in goats (Fowler et al, 1991). The decrease in milk yield (1410 kg in 36 weeks, which can be extrapolated to about 1540 kg in 44 weeks) is of similar magnitude in either absolute or relative value to the losses recorded in trials by Swanson (1965) (920 kg in the second lactation, ie 24%) and Smith et al (1967) (23%), or in studies on file data by Klein and Woodward (1943; 29%) and by Wood (1977 and 1985; 21.7 kg and 26 kg of milk /day of dry period, respectively). Explanations for the decrease in milk yield are not related to differences in body store accumulations (Swanson, 1965), nor to modifications of the general metabolism (hormone secretion; cf data of Smith et al, 1967, in a trial conducted with half-udder technique), nor to milking 'per se': Gorman and Swanson (1968) recorded a milk yield reduction similar to that observed here following dry period omission in cows administered ocytocine twice daily during the dry period but not milked during this period. According to Fowler et al (1991), reduction in milk yield consecutive to dry period omission is likely due, at least in part, to a reduced regeneration of mammary tissue, although experimental evidence for this is still lacking. In the experimental group, milk yield during the last 2 months of pregnancy in the first lactation (505 kg; see table II) compensated for only 29% of the milk loss in the following one.

The very high increase in the protein content at the beginning of the following lactation first could be attributed to the better energy balance of the cows (cf Coulon and Rémond, 1991). Nevertheless, the maintenance of the higher level during the declining phase of lactation (whereas similar increases in live weight suggest similar nutritional balance) and higher content in fat (little sensitive to energy supply) suggest a 'concentration effect', ie, a lower effect of dry period omission on fat and protein synthesis than on lactose synthesis. The lack of difference in yields of milk, fat and protein in the third lactation between control cows and cows dried off < 5 days in late second pregnancy and > 40 days in late third pregnancy confirmed that omission or reduction of dry period had an effect upon milk yield and milk composition only in the succeeding lactation, as previously observed by Swanson (1965) and Coppock et al (1974).

Nutritional indices

The lack of difference in food intake between experimental and control cows during the first 12 weeks of the second lactation is not entirely surprising, despite the notably lower milk yield in the former cows. Faverdin et al (1995) have shown that the coefficient of regression of food intake on milk yield is low during this period (about 0.13 kg DM/kg milk for second lactating cows). Moreover, in situations where udder secretion was changed by other means than feeding, long lag-times in the adaptation of

food intake to milk yield have already been observed. For instance, injections of bovine somatotropin augment milk yield within a few days but the food intake only increases after a lag-time of about 6 weeks (see review by Chilliard, 1988). Conversely, reduced milking frequency (3 times/2 days in the first 3 weeks of lactation) decreased milk yield (2.9 kg/day over the first 24 weeks of lactation) but did not reduce food intake (Rémond et al, 1992b). In both situations, as well as in this trial, cows seem to maintain their intrinsic capacity of intake for several weeks (before a likely adjustment), irrespective of their actual milk yield.

As a consequence of the lack of difference in food intake between treatments and of the much lower milk yield in experimental cows, these cows had better energy balance than the control cows. This improvement was 239 feed units for milk (FUm) for the first 9 weeks of lactation which agreed fairly well with the difference in live weight change between both groups during this period (48 kg) if we accept the energy equivalence for 1 kg live weight loss or gain proposed by Chilliard et al (1987): 4 to 6 FUm. Reduction or omission of the dry period has been shown to reduce the mobilization of energy stores in early lactation (Swanson, 1965; Farries and Hoheisel, 1989). In the beginning of lactation 3, the difference in live weight losses between groups (22 kg) could also be almost entirely explained by the higher milk yield (1.2 kg/day) although not significant and lower food intake (0.7 kg DM/day) in the experimental group. Higher energy and mineral (not calculated) balance expressed through more favourable concentrations in the blood of constituants related to energy (glucose, ketones bodies, NEFA) and mineral (calcium, phosphorus; Davicco et al, 1992) metabolism, made it possible to expect a lower incidence of nutritional deseases. In Brittany, farmers who reduced or omitted the dry period in their cows effectively observed a lower incidence of diseases related to nutrition and milk fever (survey on 17 farms; Kérouanton, unpublished data).

In conclusion, omission of the dry period over several consecutive lactations is difficult, if not impossible, to implement on all cows of a herd, unless the cows are of a higher genetic merit than those used in this trial and a diet of high nutritive value is fed during late lactation and pregnancy to support milk secretion (cf Rémond and Bonnefoy, 1997). Therefore, the concentrate that could be spared in the first part of lactation (because of the lower milk yield) should probably have to be distributed at least in part during late lactation and pregnancy. This management has the advantage of improving the energy balance of cows in early lactation (and, thereby, reducing the health problems related to nutrition), and increasing the protein content of milk and the live weight of cows which can be valuable in the case of culling. Nevertheless, it prevents the yearly cleaning of the udder with antibiotics and leads to the secretion of a milk that is rich in somatic cells and free fatty acids in late pregnancy (Rémond and Bonnefoy, 1997), and the secretion of a colostrum that is poor in immunoglobulins (Levieux and Rémond, unpublished data). It can therefore hardly be considered as a management system that is liable to be implemented in all cows, every year. In a general policy of reduced dry period (3 to 5 weeks?) it could constitute a possible management for particular cows showing a high, persistent milk yield low in cells as well as for cows that had displayed nutritional diseases (ketosis, milk fever) in preceding lactations. Reduced dry period which is more feasible and still allows the annual udder treatment with antibiotics should be more extensively studied.

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