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**Original article**

# Effect of temporary once-daily milking in early lactation on milk production and nutritional status of dairy cows

Bernard Rémond[a]*, Jean-Baptiste Coulon[a], Marlène Nicloux[a], Didier Levieux[b]

[a] Inra, Unité de recherches sur les herbivores,
[b] Inra, Station de recherches sur la viande, Theix, 63122 Saint-Genès-Champanelle, France

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**Abstract** — The effect of temporary once-daily milking, starting right after calving, on milk production and nutritional status of 50 Holstein cows (15 primiparous) was studied. Primiparous cows were divided into two groups: a control group (Pc) continuously milked twice daily and an experimental group (P3) milked once a day for the first three weeks of lactation and then twice daily. Multiparous cows were divided into three groups: a control group (Mc) continuously milked twice daily, an experimental group milked once a day for the first three weeks of lactation and then twice daily (group M3), and another experimental group milked once a day for the first six weeks after calving and then twice daily (group M6). The trial ended when the cows were turned out to pasture. Cows milked once daily did not seem to suffer from discomfort. Once-daily milking decreased the milk yield by 2.7 kg·d$^{-1}$ ($P < 0.10$) in week 1 of lactation, by 8.4 kg·d$^{-1}$ ($P < 0.01$) in week 3 and by 14.5 kg·d$^{-1}$ ($P < 0.01$) in week 6. The effect of once-daily milking was not different between primiparous and multiparous cows. During the first week of twice-daily milking, the milk yield of experimental groups increased by 6.8 kg·d$^{-1}$ (a non significant difference between P3, M3 and M6 groups). From week 7 onwards, the milk yield of the P3 and M3 groups was lower than the milk yield of the Pc and Mc groups by 2.4 kg·d$^{-1}$ ($P < 0.10$), and the milk yield of the M6 group was lower than the milk yield of the Mc group by 5.4 kg·d$^{-1}$ ($P < 0.01$). The protein content of milk was higher in experimental groups than in control groups by 2.4 g·kg$^{-1}$ during both experimental and post-experimental periods. Somatic cell counts in milk were not significantly different between the groups. Cows milked once a day lost less body condition and live weight in early lactation than control cows, and their energy balance was less negative or more positive (the difference was significant for the M6 group). The blood profile (glucose, non-esterified fatty acids, beta-hydroxybutyrate contents in plasma) attested for a better energy balance in cows milked once a day in early lactation. This trial suggests that high producing cows tolerate to be milked once a day during early lactation and that, through this management, it could

* Correspondence and reprints
Tel.: (33) 04 73 98 13 49; fax: (33) 04 73 98 13 80; remond@gentiane.enitac.fr
Present address: Ecole Nationale d'Ingénieurs des Travaux Agricoles, 63370 Lempdes, France

be envisaged to feed high producing cows with diets poorer in concentrates than what is currently given today, without impairing health. (© Elsevier / Inra).

**dairy cows / once-daily milking / early lactation / milk production / nutritional balance**

**Résumé — Effet de la traite temporaire une fois/jour en début de lactation sur la production laitière et l'état nutritionnel de vaches laitières.** Chez 50 vaches Holstein (15 primipares), nous avons étudié l'effet de la traite temporaire une fois par jour, à partir du vêlage, sur la production laitière et l'état nutritionnel. Les vaches primipares ont été réparties en deux lots: un lot témoin (Pc) trait en permanence 2 fois/j et un lot expérimental (P3) trait une fois/j pendant les trois premières semaines de lactation puis deux fois par jour. Les vaches multipares ont été réparties en trois lots: un lot témoin (Mc) trait en permanence deux fois par jour ; un lot expérimental trait une fois par jour pendant les trois premières semaines de lactation puis deux fois par jour (lot M3) ; un autre lot expérimental trait une fois par jour pendant les six premières semaines de lactation puis deux fois par jour (lot M6). L'essai s'est terminé à la fin de la période hivernale. La traite une fois par jour n'a pas semblé provoquer d'inconfort chez les vaches. Elle a diminué la production laitière de 2,7 kg·j$^{-1}$ en 1re semaine de lactation, de 8,4 kg·j$^{-1}$ en 3e semaine, et de 14,5 kg·j$^{-1}$ en 6e semaine. Son effet n'a pas été différent entre les vaches primipares et multipares ($p > 10$ %). Dès la première semaine de traite deux fois·j$^{-1}$, la production laitière des vaches expérimentales a augmenté de 6,8 kg·j$^{-1}$ (différence non significative entre les lots P3, M3 et M6). À partir de la semaine 7 la production laitière des lots P3 et M3 a été, en moyenne, plus faible que celle des lots Pc et Mc de 2,4 kg·j$^{-1}$ en moyenne, et celle du lot M6 a été plus faible que celle du lot Mc de 5,4 kg·j$^{-1}$ en moyenne. Le taux protéique du lait des vaches traites une fois par jour a été plus élevé que celui des vaches témoins, de 2,4 g·kg$^{-1}$ pendant les périodes expérimentale et post-expérimentale. Le nombre de cellules somatiques dans le lait n'a pas été significativement différent entre les lots. Les vaches traites une fois·j$^{-1}$ ont perdu moins d'état corporel et moins de poids vif en début de lactation que les vaches témoins, et elles ont présenté un bilan énergétique moins négatif ou plus positif (différence significative pour le lot M6). Le profil sanguin (teneurs en glucose, acides gras libres, 3-hydroxybutyrate) a attesté un meilleur équilibre énergétique des vaches traites une fois par jour en début de lactation. Cet essai suggère que les vaches fortes productrices supportent sans inconvénient apparent d'être traites une fois par jour pendant le début de la lactation et qu'il pourrait être envisageable d'alimenter ces animaux avec des régimes plus pauvres en concentrés que maintenant, sans accroissement des risques sanitaires. (© Elsevier / Inra).

**vache laitière / traite une fois par jour / début lactation / production laitière / bilan nutritionnel**

## 1. INTRODUCTION

The current milk quota policy in the European Community determines the volume of milk each farmer may sell and, consequently, his income. The main way to improve this income is, now, to reduce the cost of milk production and, in particular, the cost of feeding. For this reason milk producers try more than ever to increase the forage contribution in the diet by reducing the quantity of concentrates offered. This feeding strategy inevitably leads to a growing negative energy balance in cows in early lactation and, consequently, to a higher probability of health incidents, reproductive failure and low protein content in milk. To avoid these unacceptable drawbacks, it could be judicious to temporarily reduce the quantity of milk that the udder secretes, in order to adapt it to the lower quantity of nutrients that the cow ingests. The most powerful tool in reaching this adjustment is to reduce the milking frequency.

Omission of one milking out of four for the first three weeks of lactation in order to improve the energy balance of the cows results in a very weak effect on milk yield (about 3 kg·d$^{-1}$ in primiparous cows, and less than 1 kg·d$^{-1}$ in multiparous; [21, 22]).

Once-daily milking decreases the yield of milk in a larger manner, that tends to be more pronounced in early or mid lactation than in late lactation (38 versus 28 % respectively, for Stelwagen and Knight [30]; 14 to 17 % versus 9 to 13 % respectively, for Carruthers et al. [3]). Nevertheless, these decreases are variable according to trials, from 7 to 33 % [1, 7, 16, 19, 27]. The decrease in milk yield appears to be more marked as the duration of the milking omission becomes longer [3, 5], but not always [7]. High producing cows are more sensitive to this treatment than low producing cows according to Claesson et al. [5]; however Holmes et al. [10] observed the contrary, whereas Knight and Dewhurst [16] did not observe any influence of the level of milk production. When cows are milked twice daily after a period of once-daily milking, milk yield resumes completely [16], incompletely [7, 27] or very little [5] according to the duration of once-daily milking period.

The great variety in the experimental conditions (duration of once-daily milking, production level of the cows, stage of lactation) probably explains the variability in the observed effects. Nevertheless, no experiment was conducted on the effect of once-daily milking for a few weeks immediately after calving, followed by a conventional milking regime (twice daily), in order to level off the peak of lactation, thereby improving the energy status of the cows.

In this study, we examined the performance and the nutritional status of primiparous and multiparous cows milked once a day for the first 3 or 6 weeks of lactation and then twice daily.

## 2. MATERIAL AND METHODS

### 2.1. Cows and experimental protocol

Fifteen primiparous cows (38 months old at calving) and 35 multiparous cows (mean parity: 3.4) of the Holstein-Friesian breed were used. They calved between 30 October 1996 and 4 March 1997 (22 December 1996 on the average). Primiparous cows were allocated at calving to two groups according to expected calving date, the genetic index for milk yield and fat and protein contents, and live-weight: a control group milked twice a day over the trial (group Pc) and a group milked once a day for the first three weeks of lactation and then twice daily (group P3). Multiparous cows were divided into three groups according to the expected calving date, parity, milk yield and its content in protein recorded during the beginning of the preceding lactation, and live-weight. The groups were a control group milked twice a day during the trial period (group Mc), a group milked once a day for the first 3 weeks of lactation and then twice daily (group M3), and a group milked once a day for the first 6 weeks of lactation and then twice daily (group M6). The trial ended when cows were turned out to pasture on 28 April 1997.

Throughout the rest of this article, we will call 'control cows' (control group) the cows continuously milked twice daily, and 'experimental cows' (experimental group) the other cows. Similarly, we will call the 'experimental period' the period for which once-daily milking was applied, and 'postexperimental period' the following period of twice-daily milking.

### 2.2. Herd management and feeding

Cows were returned from pasture into the barn at least 4 weeks before the expected calving date, and no later than 10 November 1996. During the winter period, they were housed in two free-stall barns either equipped with electronic gates permitting individual control of food intake (for multiparous cows) or without electronic gates (for primiparous cows). All cows were fed in the same manner, with the same feeds. During late pregnancy (indoor) cows received cocksfoot silage ad libitum and, for the last three weeks before calving, an increasing quantity of concentrates according to the 1989 Inra recommendations. During lactation in the barn, they received the same complete diet composed (on a dry matter (DM) basis) of 42 % grass silage, 23 % maize silage, 12 % hay from re-growth of natural pasture and 23 % of a commercial concentrate (see chemical composition in *table I*). The energy value of this diet was estimated at 0.90 FUm·kg$^{-1}$ DM, and its crude protein content (N. Kjeldahl * 6.25) was 15.3 %. This diet was calculated using the software Inration [12] based on 1989 Inra feeding allowances [11]. It was pre-

**Table I.** Chemical composition of the feeds.

| Feed | Dry matter (%) | Organic matter (% DM) | Crude protein (% DM) | Crude fiber (% DM) |
|---|---|---|---|---|
| Grass silage | 25 | 89.1 | 16.0 | 31.1 |
| Maize silage | 30 | 95.3 | 7.1 | 21.1 |
| Hay (regrowth) | 85 | 91.5 | 17.2 | 28.7 |
| Concentrate | – | 92.1 | 21.3 | 11.4 |

pared in a desiling-mixing-distributing machine equipped with strain gauges and distributed once daily, ad libitum, between 9:00 and 10:00.

Milkings were between 6:00 and 7:30 and 16:30 and 18:00 in a milking parlour equipped with automatic cluster removers and jars on strain gauges. In the case of mastitis, antibiotics were injected in the injured quarter.

## 2.3. Measurements and samplings

Milk yield was weighed at each milking. Fat, protein and lactose were measured by infra-red spectrophotometry (Milkoscan 4000; Foss System, Hillerod, Denmark), two days per week in each milk sample. In the same samples, somatic cells were automatically counted (Fossomatic 5000; Foss System; Hillerod, Denmark). During weeks 3, 6 and 12 of lactation, supplementary samples of milk were taken at the morning milkings. Casein N was calculated as the difference between total N and soluble N measured according to Rowland [24]. Immunoglobulins (IgG1) and serum albumin were measured by the radioimmunoassay technique [18].

Food intake was measured four days per week in multiparous cows. Cows were weighed twice in the first week after calving and every other week thereafter, on Wednesday early in the afternoon. Body condition was scored on a 0 (very lean) to 5 (very fat) scale at weeks 1 and 8 or 9 after calving. Energy balance of multiparous cows was calculated by difference between energy intake (food intake – estimated energy content of the diet) and energy utilisation (maintenance + milk yield) [11]. Energy in milk was calculated according to Sjaunja et al. [25], taking into account protein, fat and lactose contents. In order to estimate the metabolic status of the cows, glucose, beta-hydroxybutyrate and non-esterified fatty acids were determined in the plasma with an ELAN auto-analyser (Merck-Clévenot SA, France) by enzymatic methods (see [2]). Blood samples were taken during week 3 of lactation, at about 9:00, before diet distribution.

## 2.4. Statistical analysis

One cow from the M3 group broke a leg and was culled from the experiment. Data (on 49 cows) were submitted to analysis of variance using the GLM procedure [26]. Analysis of somatic cell counts was done on logarithmically transformed data. Because of the unbalanced experimental scheme (two groups of primiparous cows, three groups of multiparous), all data from these two categories of cows were analysed separately, except data on blood constituents. In analysing milk data from multiparous cows, performances from the preceding lactation were used as covariates.

The lactation time in the barn was divided into several consecutive periods: weeks 1 to 3, 4 to 6, 7 to 12 and 13 to 18. This last period only comprised the earliest calved cows, i.e., 4 and 5 cows in the Pc and P3 groups respectively, and 6, 4 and 8 cows in the Mc, M3 and M6 groups, respectively. Six cows (from 34) were turned out to grass before the 13th week of lactation. Their feed intakes were extrapolated.

# 3. RESULTS AND DISCUSSION

According to the technicians who cared for the cows, separating the cows milked once a day from the rest of the herd before afternoon milking did not pose any problem. They did not try to follow their mates to the milking parlour, nor did they vocalise. Before the morning milking (24 h after the preceding milking), behaviour of twice and

once daily milked cows did not differ, suggesting that the latter did not suffer from discomfort. In a trial where they omitted one or two milkings weekly, Radcliffe et al. [20] noted that cows ceased to manifest a different behaviour after three weeks of once-weekly milking omission. In this trial, beginning once-daily milking at calving could have made the adaptation of the cows to this type of management easier.

### 3.1. Milk yield

Once-daily milking decreased the quantity of milk secreted (*figure 1* and *table II*). The difference between control groups and once-daily milked groups increased with the length of the milking regime implementation. It increased from 2.7 $kg \cdot d^{-1}$ ($P < 0.10$) at week 1 of lactation to 8.4 $kg \cdot d^{-1}$ ($P < 0.01$) at week 3 (means are for primiparous and multiparous (M3 + M6) cows combined for which the difference was not significant), and to 14.5 $kg \cdot d^{-1}$ ($P < 0.01$) at week 6 of lactation (comparison between M6 and Mc groups). The amplitude of the negative effect of once-daily milking observed in this trial (25 % at week 3 and 40 % at week 6) was of the same order as those observed by Claesson et al. [5] during the same physiological period and by Stelwagen and Knight [30] with high producing cows in early lactation. The effect of once-daily milking, that increases with duration of treatment, was previously observed by Claesson et al. [5] and Rémond and Boit [22], who also reduced milking frequency from calving onward. During the declining phase of lactation, a decrease in milk yield resulting from short-term (2 to 3 weeks) once a day milking should be due, at least partly, to a decrease in the secretory activity of mammary cells without modification of their number [29, 34]. Just after calving (during the ascending phase of lactation), the cause of milk secretion reduction as a result of once a day milking remains to be determined. During this period, the number of secretory cells increases, at least in primiparous goats [14] and they become differentiated (see [15]). Stelwagen et al. [27, 29] suggested that the decrease in the milk yield is partially due to the loss of integrity of tight junctions in mammary tissue, evidenced in their studies by an increased content of serum albumin in milk or alpha-lactalbumin and lactose in blood. In our study, the increase in the content of serum albumin in milk was much less marked and systematic (*table III*), perhaps because once-daily milking was implemented immediately after calving and that cows could progressively adapt.

The change from once to twice-daily milking entailed a large and rapid increase in the milk yield (*figure 1*), which was of a similar magnitude in the 3 groups. In one week (from week 3 to week 4 for groups P3 and M3, and from week 6 to week 7 for group M6) this increase was 6.8 kg (no significant difference between the 3 groups). During weeks 7 to 18, lactation curves of different groups evolved in a parallel manner. Temporary decreases of milk yield in group M3 during weeks 14 to 16 were due to 2 of the 4 cows during this period (see Material and Methods, § Statistical analysis) suffering from mastitis (see later). In postexperimental periods, the milk yields of groups milked once a day for 3 weeks (P3 and M3) was lower than milk yields of control groups (Pc and Mc), by 2.3 kg on the average ($P < 0.10$ or at the limit of 0.10, depending upon the periods) (*table II*). Milk yield of M6 cows during the postexperimental period was lower than that of the control group by 5.4 $kg \cdot d^{-1}$ on the average ($P < 0.01$). The growing residual effect (significant or not) with the length of the treatment implementation, that we observed, agrees with the literature: a reduced milking frequency had a longer and larger residual effect as it was implemented sooner in lactation and over a longer period [5, 31, 32, 33]. The lack of difference in the effect of omission of one milking·$d^{-1}$ between primiparous and multiparous cows confirms our preceding obser-

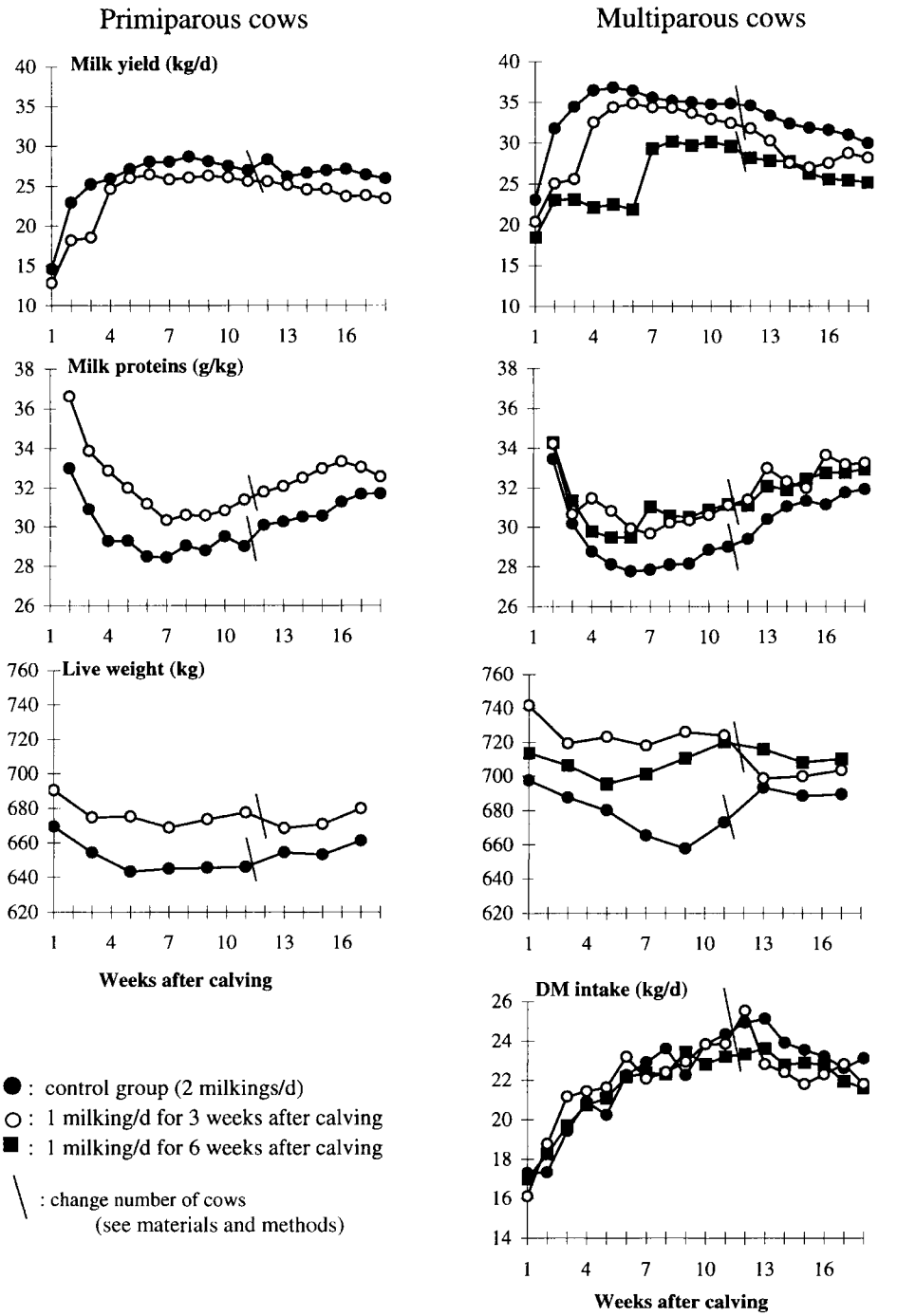


**Figure 1.** Evolution of milk yield and protein content, live weight, and dry matter intake in the first 18 weeks after calving.

**Table II.** Effect of once-daily milking on milk yield and composition.

| | Parity | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | | ≥ 2 | | | |
| Number of milkings·d$^{-1}$ | 2 (control) | 1 | Root MSE | 2 (control) | 1 (for 3 weeks) | 1 (for 6 weeks) | Root MSE |
| Milk (kg·d$^{-1}$) | | | | | | | |
| week 1 to 3 | 20.9 A | 16.5 B | 3.1 | 29.8 A | 23.7 B | 21.5 B | 4.2 |
| week 4 to 6 | 27.0 | 25.7 | 3.7 | 36.6 Aa | 33.9 Ab | 22.2 B | 3.5 |
| week 7 to 12 | 27.9 a | 25.9 b | 3.3 | 35.0 A | 33.2 ABa | 29.5 Bb | 5.1 |
| week 13 to 18 | 26.5 lim a | 24.2 lim b | 3.7 | 31.6 a | 28.2 ab | 26.3 b | 5.1 |
| Lactose (g·kg$^{-1}$) | | | | | | | |
| week 2 and 3 | 49.7 a | 47.9 b | 1.8 | 48.8 a | 48.4 ab | 47.2 b | 1.9 |
| week 4 to 6 | 50.9 | 50.7 | 1.6 | 49.3 A | 49.7 A | 46.6 B | 2.0 |
| week 7 to 12 | 51.0 | 51.2 | 1.5 | 50.0 a | 49.6 ab | 48.4 b | 2.1 |
| week 13 to 18 | 51.0 | 51.2 | 1.2 | 50.2 a | 49.5 a | 48.5 a | 2.1 |
| Fat (g·kg$^{-1}$) | | | | | | | |
| week 2 and 3 | 46.2 | 44.9 | 5.7 | 47.1 A | 53.0 Ba | 48.9 AB | 5.1 |
| week 4 to 6 | 42.2 | 42.3 | 3.7 | 43.3 A | 44.6 AB | 47.0 B | 4.0 |
| week 7 to 12 | 39.8 | 39.3 | 2.9 | 40.7 A | 43.2 B | 41.4 AB | 2.6 |
| week 13 to 18 | 40.1 | 39.9 | 4.1 | 41.8 | 45.0 | 40.9 | 3.9 |
| Proteins (g·kg$^{-1}$) | | | | | | | |
| week 2 and 3 | 31.9 A | 35.2 B | 2.0 | 31.5 | 32.5 | 33.1 | 2.5 |
| week 4 to 6 | 29.0 A | 32.0 B | 1.8 | 27.9 A | 30.8 B | 29.9 B | 1.9 |
| week 7 to 12 | 29.1 a | 30.9 b | 1.6 | 28.1 A | 30.6 B | 31.3 B | 2.1 |
| week 13 to 18 | 31.0 A | 32.7 B | 0.5 | 30.1 Aa | 32.8 ABb | 33.5 B | 2.2 |
| Somatic cells (log·mL$^{-1}$) | | | | | | | |
| week 3 to 6 | 5.32 | 5.05 | 0.36 | 5.17 | 5.24 | 5.30 | 0.59 |
| week 7 to 12 | 5.30 | 5.22 | 0.53 | 5.25 | 5.53 | 5.34 | 0.59 |
| week 13 to 18 | 5.26 | 5.30 | 0.61 | 5.18 | 5.79 | 5.67 | 0.61 |

Means with different capital letters are different at the 0.05 level of significance. Means with different lower case letters are different at the 0.10 level. Number of cows: 15 primiparous and 34 multiparous until week 12; 9 primiparous and 18 multiparous from week 13 onwards. In multiparous cows, milk yield, fat and protein contents in milk during the preceding lactation were used as a covariate in the statistical analysis of the corresponding items. Statistical analysis on somatic cells was done on logarithmically transformed data.

vations [22]. Nevertheless, Claesson et al. [5] observed a more important decrease in first lactation (50 %) than in the second one (40 %). Implementing three milkings/two days, Woolford et al. [35] also noticed a more accentuated reduction of milk yield in primiparous cows (18 %) than in multiparous (7 %) over a complete lactation.

### 3.2. Milk composition

Once-daily milking decreased lactose content as previously recorded [3, 5, 10, 27]. It increased fat content (in multiparous cows only), as observed, significantly or not, by Holmes et al. [10] and Carruthers et al. [3] but not by Claesson et al. [5] nor by

**Table III.** Effect of once-daily milking on the milk protein content.

| | Parity | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | | ≥ 2 | | | |
| Milkings·d$^{-1}$ | 2 (control) | 1 | Root MSE | 2 (control) | 1 (for 3 weeks) | 1 (for 6 weeks) | Root MSE |
| Casein (g·kg$^{-1}$) | | | | | | | |
| week 3 | 25.8 | 26.9 | 1.5 | 25.0 | 25.5 | 25.9 | 1.4 |
| week 6 | 23.9 A | 26.1 B | 1.5 | 22.8 A | 25.6 B | 24.6 B | 1.9 |
| week 12 | 25.5 | 26.7 | 2.1 | 24.9 | 25.7 | 26.2 | 2.5 |
| Whey proteins (g·kg$^{-1}$) | | | | | | | |
| week 3 | 6.0 a | 7.5 b | 0.8 | 5.3 A | 6.5 B | 6.4 B | 1.1 |
| week 6 | 5.5 | 5.9 | 0.8 | 5.7 | 5.7 | 5.8 | 0.7 |
| week 12 | 5.9 | 6.5 | 0.8 | 5.7 a | 6.5 b | 6.4 b | 0.9 |
| Casein/proteins (%) | | | | | | | |
| week 3 | 81.0 A | 78.3 B | 2.1 | 82.4 aA | 79.6 B | 80.0 bB | 2.7 |
| week 6 | 81.6 | 81.6 | 2.3 | 79.9 | 81.7 | 81.1 | 2.3 |
| week 12 | 81.0 | 80.5 | 3.1 | 81.3 | 79.8 | 80.6 | 2.6 |
| Serum albumin (mg·L$^{-1}$) | | | | | | | |
| week 3 | 248 A | 381 B | 98 | 212 | 229 | 249 | 54 |
| week 6 | 148 | 177 | 50 | 133 A | 176 A | 248 B | 36 |
| week 12 | 167 | 167 | 25 | 159 | 179 | 204 | 46 |
| Immunoglobulins G1 (mg·L$^{-1}$) | | | | | | | |
| week 3 | 588 A | 972 B | 255 | 539 | 500 | 606 | 167 |
| week 6 | 537 | 566 | 179 | 382 A | 465 AB | 567 B | 103 |
| week 12 | 403 | 445 | 91 | 335 | 384 | 414 | 105 |

Means with different capital letters are different at the 0.05 level of significance. Means with different lower case letters are different at the 0.10 level.

Wheelock et al. [33]. It also increased protein content (by 2.4 g·kg$^{-1}$ on average) during both experimental and postexperimental periods (*figure 1* and *table II*), as observed in most trials [5, 10, 19, 27]. This increase in the protein content was due to an increase in whey proteins rather than to an increase in caseins, – despite this protein fraction also increased –, at least during the period of reduced milking frequency (*table III*). In agreement with the higher total whey protein content, both bovine serum albumin and immunoglobulins G1 were increased with once-daily milking (*table III*). It follows that the casein/protein ratio was significantly lower at week 3 of lactation in once-daily milked cows (*table III*). These shifts in protein content and composition have been previously observed [1, 5, 10, 27] and are consistent with the changes recorded by Wheelock et al. [33] after a suspension of milking for 24 to 60 h. These modifications could result from the effect of once-daily milking on: 1/ the energy balance (increased; see later) of the cows [6]; 2/ the rates of lactose synthesis and protein synthesis by the mammary tissue that could have been differently affected; 3/ the leakage of lactose

from milk to blood [29], that should decrease the volume of milk secreted; 4/ the leakage of proteins from blood to milk [27] that should increase the non casein fraction of milk.

As a consequence of increased protein and fat contents, the yield of these constituents by experimental cows decreased less than the yield of milk did. During weeks 4 to 18, yields of proteins and fat by P3 and M3 groups (average) were respectively only 11 $g \cdot d^{-1}$ (1.1 %) and 51 $g \cdot d^{-1}$ (4.1 %) lower than the yields by the control groups (Pc and Mc).

### 3.3. Food intake

Despite large differences in milk yield, food intake (only measured in multiparous) was not different for the 3 groups during any of the first 18 weeks of lactation (*figure 1*). For the first 12 weeks of lactation, intakes (adjusted means) were 21.2 kg, 21.5 kg and 21.6 kg $DM \cdot d^{-1}$ for Mc, M3 and M6 groups, respectively. In the statistical analyses, the live weight on week 1 of lactation, the milk yield during the preceding lactation, and the milk yield during the experimental period, used as covariates, were not significant.

This finding was in contrast with positive relationships between milk yield level and intake level observed previously (see [13]). In fact, these positive relationships were always calculated from data where milk yields expressed the genetic capacity of the cows to produce milk. This is not the case in this trial where differences in milk yield resulted from management. The intake data in the present study are consistent with those in a trial where cows were not dried off in late pregnancy. Their food intake at the beginning of the following lactation period was similar to the food intake of conventionally managed control cows (dried off for about 2 months), despite the fact that control cows produced 7.6 $kg \cdot d^{-1}$ more milk [23]). Moreover, Chilliard [4] observed that administration of growth hormone to dairy cows almost immediately increased milk yield by several $kg \cdot d^{-1}$ whereas food intake increased only after more than one month. So it appears that the quantity of food ingested adapts after a lag period to a variation in milk yield which is due to a particular management practice (e.g., omission of dry period, modification of the milking frequency, administration of growth hormone). The regulation mechanism seems to implicate the level of body reserves (see [9]). Nevertheless, with cows at pasture, Holmes et al. [10] observed that once-daily milked cows ingested less grass than twice-daily milked ones.

### 3.4. Nutritional indices

As a consequence of the significant drop in milk yield while food intake was maintained, the energy balance was less negative or more positive in once-daily milked cows than in control cows (*table IV*). Losses of body condition and of live weight in early lactation (first 2 to 3 months) were lower (albeit not always significantly) in cows milked once a day in early lactation than in control cows, which is consistent with a less negative or more positive energy balance. This effect was bigger in multiparous cows and in the M6 treatment group (*figure 1* and *table IV*). Different authors [5, 10, 19] had already observed a smaller liveweight loss as a result of a reduction in milking frequency. Once-daily milking caused a decrease in the plasma content of non-esterified fatty acids and beta-hydroxybutyrate, and an increase in glucose (*table V*). These changes, consistent with the better nutritional status of the cows, were significant only in multiparous cows.

### 3.5. Health status

Somatic cell counts were not statistically different between the groups (*table II*). High cell counts in experimental multiparous

**Table IV.** Effect of once-daily milking on body condition score, body weight changes and energy balance in early lactation.

| | Parity | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | | ≥ 2 | | | |
| Milkings·d$^{-1}$ | 2 (control) | 1 | Root MSE | 2 (control) | 1 (for 3 weeks) | 1 (for 6 weeks) | Root MSE |
| Body condition score change (week 8 – week 1) | – 0.8 | – 0.8 | 0.8 | – 1.3 a | – 0.8 ab | – 0.5 b | 1.0 |
| Body weight change (kg) (week 11 – week 1) | – 23.0 | – 12.9 | 38.0 | – 25.8 A | – 17.1 ABa | + 6.8 Bb | 31.6 |
| Energy balance (FUm/day) | | | | | | | |
| week 2 to week 6 | nc | nc | | – 3.7 A | – 1.9 B | 1.9 C | 1.8 |
| week 7 to week 12 | nc | nc | | – 0.6 A | – 0.3 A | 1.4 B | 1.8 |
| week 13 to week 18 | nc | nc | | 1.5 | 1.4 | 2.7 | 1.6 |

nc: not calculated (food intake not available)
Means with different capital letters are different at the 0.05 level of significance. Means with different lower case letters are different at the 0.10 level.

**Table V.** Effect of once-daily milking on the plasma content in some constituents at week 3 of lactation.

| | Parity | | | | |
|---|---|---|---|---|---|
| | 1 | | ≥ 2 | | Root |
| Milkings·d$^{-1}$ | 2 (control) | 1 | 2 (control) | 1* | MSE |
| Glucose (g·L$^{-1}$) | 0.64 A | 0.66 Aa | 0.50 B | 0.60 Ab | 0.07 |
| Non esterified fatty acids (mmole·L$^{-1}$) | 0.35 ABa | 0.24 A | 0.62 Bb | 0.35 A | 0.30 |
| Beta-hydroxybutyrate (mmole·L$^{-1}$) | 0.83 AB | 0.67 A | 1.43 B | 1.07 AB | 0.79 |

* Data from M3 and M6 groups of cows have been pooled in the statistical analysis.
Means with different capital letters are different at the 0.05 level of significance. Means with different lower case letters are different at the 0.10 level.

groups around week 15 of lactation were due to 3 cows (out of 4) of the M3 group for which somatic cell counts were over $2 \times 10^6$·mL$^{-1}$. In the M6 group, the high cell counts were because 3 cows (out of 8) had somatic cell counts over $4*10^6$·mL$^{-1}$ (*table II*).

Many cases of mastitis occurred during the trial. During the first 12 weeks of lactation when all cows were included, mastitis affected 9 of the 19 control cows (11 mastitis in total) and 10 of the 30 experimental cows (15 mastitis in total). During weeks 13 to 18 where the number of cows was reduced (see Materials and methods), mastitis affected 3 of the 10 control cows (3 mastitis in total) and 9 of the 17 experimental cows (11 mastitis in total). The drop in the milk yield

curve of group M3 around week 15 was due to the fact that this group was then only composed of 4 cows, 2 of which were suffering from mastitis. Three multiparous control cows suffered from milk fever. The fact that no cases of milk fever were found in experimental groups is consistent with the improved nutritional status of experimental cows.

In the literature, a reduction of milking frequency or the periodic omission of milkings increased somatic cell counts [10, 20, 28] and even the number of cells secreted in milk [28]. However, they did not augment the damage to secretory cells [28] nor the number of udder infections [8, 10, 17, 20, 31].

## 4. CONCLUSION

This trial shows that once-daily milking of high producing cows from calving: i) is possible and does not seem to cause discomfort for cows; ii) permits to transiently reduce the milk yield; iii) only moderately reduces the capacity of the udder to produce milk after resumption of twice-daily milking if omission only lasts for about 3 weeks; iv) does not change the food intake of the cows. These results allow one to envisage feeding high producing cows with diets richer in forages than today, while markedly reducing risks of health incidents and reproductive failure related to the nutritional deficit in early lactation. These effects need to be confirmed, in particular when diets very low in concentrates are utilised. Moreover it is necessary to specify the possible consequences of such management on milk quality (in particular on the secretion of lipolytic and proteolytic enzymes) and on the health (mastitis) and longevity of the udder.

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