Dairy cows health and production performances according to the concentrate level. Three series of experiments led in Trévarez experimental farm, France.

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ABSTRACT
Three 3-years experiments were led from 1992 to 2001 on the dairy herd of Trévarez experimental farm (Brittany, western France) in order to find technical solutions to decrease the production costs. A decreased concentrate level (from 1,600 to 300 kg/cow/yr) was thus combined to an increased part of grazed grass in the forage diet (from 0.25 to 0.4 ha/cow). The reduced concentrate level led to an average decrease in the dairy production by 0.9 kg of milk per kg of saved concentrate, as well as a slight decrease in the protein content and an increase in the fat content of the milk. The higher part of grazed grass within the forage system led to a lower production level, and lower milk solids concentrations.
The occurrences of the main health disorders, as well as the reproduction performances, did not differ significantly among the experimental groups. But they appeared to be influenced by the following criteria : body condition score at calving, dairy production at peak, parity, and the sanitary « history » of the animal.

KEY WORDS : feeding cost, concentrate level, grazed grass, dairy production, fertility, health disorders, dairy cows.

FIELD IMPLICATIONS

Feeding strategies with a minimal level of concentrate (and/or a maximal level of grazed grass) lead to good dairy productions (close to the averages recorded at Milk Performance Recording) with a reduced feeding cost and without any negative impact on reproduction performances or health. These experiments clearly underline that the implementation of a well balanced diet, delivered ad libitum and with scheduled transition phases can guarantee good sanitary results whatever the dairy production level of the cows. Whatever the feeding strategy, decreasing the occurrence of health disorders requires an efficient monitoring of the animals from calving onwards, in order to stop the cycle of health disorders appearing in early lactation.

1- INTRODUCTION

Since 1990, the evolution of the economical background led the dairy producers to optimise their profits by decreasing the production cost per litre of milk. In a specialised dairy farm, the feeding cost constitutes 55 to 70 % of the variable costs *(Brocard et al, 2000).* Producing most of the quota by one's own forages is then an efficient way to limit inputs and overall costs. But it requires to accept a dairy production level mainly depending on the forages quality and quantity, and to forget the search for a maximal expression of the dairy genetic merit. This choice was made in the Breton experimental farm of Trévarez (France) during long term experiments led by the EDE-Chambres d'Agriculture de Bretagne (extension services) together with the French Institut de l'Elevage (applied research institute). The aim consisted in evaluating the effects of the concentrate level (and/or the part of grazed grass in the forage diet) on dairy cows performances (milk, health, reproduction) at the lactation or at the whole production life scales.

2- MATERIAL AND METHODS

21- Introduction to the experiments

Trévarez experimental farm is located in Brittany, western France, and its dairy herd is composed of 140 Holstein cows. Most of the cows are calving during the autumn ; in winter the cows are housed in a cowshed with cubicles (loose housing).

Three three-years trials took place in Trévarez from 1992 to 2001 (table 1). Three concentrate levels were compared : 300, 650, and a control group which was chosen to be close to the average concentrate deliveries registered at Milk Performance Recording (1,600, 1,350 and 1,100 kg per lactation according to the time series); from 1998 onwards, two parts of grazed grass in the forage system were also compared : 0.25 vs 0.40 ha of grazed grass per cow per year. The three series were run independently one from the other though they immediately followed each other : new groups of cows were constituted at each start of a series of 3-years trials. However, primiparous cows were introduced every year in the experimental groups in order to compensate the culled cows (only compulsory culling causes were accepted).

*Table 1 : The experimental groups during the 3X3 years series (kg of concentrate/cow/year * part of grazed grass ha/cow/year)*

Year	Control group	Experimental group « a »	Experimental group « b »
1992-1995	1,600 * 0.25	650 * 0.25	
1995-1998	1,350 * 0.25	650 * 0.25	
1998-2001	1,100 * 0.25 & 1,100 * 0.40	650 * 0.25 & 650 *0.40	300 * 0.25 & 300 * 0.40

22- Forage systems and concentrates

In the "0.25 ha of grass per cow" group, grazed grass constituted the only forage of the diet during two months and the winter diet was only based on maize silage. In the "0.40 ha of grass per cow" group, all the animals could remain during four months on a 100% grazed grass diet ; in that case the winter diet was made of a mixed ration (grass silage / maize silage).

The maize diet was balanced in proteins with soya or a protected rapeseed + urea mix, delivered together with the maize. The individual concentrates were delivered with an automatic concentrate feeder ; their composition changed over time according to the series of trials : a commercial concentrate was delivered to the control group from 1992 à 1998, a mixing of "wheat + soya" for the experimental groups from 1992 to 1998 and for all the groups from 1998 to 2001. More information about the concentrate schemes are available from the authors. (*Brocard, 1999 ; Jurquet, 2002)*.

23- Data acquisition

Dairy performances (solids and milk) were measured twice a week. Body condition scores (Bazin et al, 1984) were assessed once a month and shortly before calving.

Health occurrences were registered daily on individual leaflets by the farm's staff and were checked by a diagnosis when worked out. The only reproduction criterion statistically analysed was failure at first AI (*Schmidt, 2002)*.

The sequences of forages delivered to the cows before the diseases were restored thanks to the yearly forage calendars.

Altogether over a nine years period, 998 lactations lasting at least 36 weeks were validated and studied in terms of dairy production ; 1152 lactations over 90 days were studied in terms of health disorders, and 1048 lactations exceeding 90 days in terms of fertility.

24- Data valorisation

Production data were analysed according to a mixed linear model with repeated measures on cows. The adjusted means for non corrected milk and fat and protein contents emanating from the "within-trial" analyses were studied in order to establish response laws according to the concentrate level and the parity.

The sanitary events (absence or presence) were analysed with multivariate logistic regression models (*Araujo, 2003*). The explicative variables were the following : parity, year, the health disorders which occurred earlier in the lactation, the sequences of forages delivered to the cow before the disorder, added to two groups of variables only included in two alternative models :

1. the first one included the concentrate level and the part of grazed grass, thus representing the type of feeding management of the experimental groups,
2. the second one included the body condition score at calving, its maximal loss after calving, milk peak, and the minimal protein on fat ratio in the 90 first days of lactation.

The variables were selected stepwise thanks to a descending elimination procedure (signification threshold : P<= 0.10).

3- RESULTS

31- Animal performances

During winter periods, the decreased concentrate level led to an increased forage intake but a decreased total dry matter intake of the diet. The substitution rate reached 0.45 (resp. 0.5) in 1992-1995 (resp. 1995-1998), but only 0.3 in 1998-2001. Yearly intakes varied according to the groups from 6,100 à 7,100 kg of DM. Compared to the multiparous cows of the "0.25 ha", the "0.40" ones had an extra intake of 580 kg DM of grazed grass and of 580 kg DM of grass silage with a decreased intake of maize silage (- 1,460 kg DM).

Both the concentrate level and the parity significantly influenced the amount of milk produced by the cows ($P < 0.0001$, table 2). The decrease in the concentrates led to a decrease in the milk production by –1.17 kg ok milk per kg of saved concentrates (multiparous cows) and by –0.42 kg milk/kg of concentrate (primiparous cows). The part of grass in the forage system did not modify the cows response to the concentrate level (no significant forage*concentrate interaction). Whatever the concentrate level, the "0.25" grass group produced more milk than the "0.40" (+1.5 kg, table 2, $P < 0.01$).

Table 2 : Daily non corrected milk production adjusted from parity and genetic merit

	Concentrate levels (kg/cow/year)			
	300 group	650 group	Control group[1]	Mean
1992-95	-	22.3	25.2	-
1995-98	-	23.3	26.2	-
1998-01 0.4 ha	22.1	23.6	24.9	23.5
1998-01 0.25 ha	23.8	24.4	26.8	25.0

[1] : 1,600 kg in 1992-95, 1,350 kg in 1995-98 and 1,100 kg in 1998-01

The cows belonging to the "low concentrate group" showed good dairy performances and produced 7,300 kg of milk per year (multiparous cows) with 300 kg of concentrate and 0.25 ha of grazed grass/cow (control group : 8,200 kg of milk with 1,150 kg of concentrate and 0.25 ha of grazed grass/cow).

Both the concentrate level and the parity influenced the fat content of the milk ($P < 0.005$, table 3). The decrease in the concentrates led to a higher fat content (+0.25 g/kg for 100 kg of saved concentrates per year). The decrease appeared to be the same whatever the part of grazed grass in the forage system. A higher part of grazed grass in the forage system (0.40 vs 0.25 ha/cow) led to a lower fat content (-1 g/kg, $P < 0.01$).

Both the concentrate level and the parity influenced the protein content of the milk ($P < 0.003$, table 3). The decrease in the concentrates led to a lower protein content (-0.08 g/kg for 100 kg of saved concentrates per year). A higher part of grazed grass in the forage system (0.40 vs 0.25 ha/cow) led to a lower protein content (-0.6 g/kg, $P < 0.01$).

No significant difference in terms of body condition at calving (table 4) or maximal loss after calving was noticed among the various concentrate or grass groups. Whatever the concentrate group, body conditions scores at calving were quite weak and regularly decreased since 1992. Body condition losses after calving were thus also weak (-0.8 to 1.1 point).

Table 3 : Fat and protein contents (adjusted from parity and genetic merit), 36 weeks of lactation, g/kg.

	Concentrate levels (kg/cow/year)							
	300 group		650 group		Control group[1]		Mean	
	FC	PC[2]	FC	PC	FC	PC	FC	PC
1992-1995	-	-	41.5	31.4	39.6	31.9	-	-
1995-1998	-	-	42.3	32.3	40.4	32.3	-	-
1998-01 0.4 ha	40.5	30.8	39.7	31.0	39.0	32.1	39.7	31.3
1998-01 0.25 ha	41.6	31.5	41.4	31.9	39.2	32.5	40.7	32.0

[1] : 1,600 kg in 1992-95, 1,350 kg in 1995-98 and 1,100 kg in 1998-01 ; [2] true protein content

Table 4 : Body condition score after calving according to the concentrate level

	Concentrate levels (kg/cow/year)			
	300 group	650 group	Control group[1]	Means[2]
1992-95	-	3.4	3.4	-
1995-98	-	3.2	3.3	-
1998-01 0.4 ha	3.1	3.1	3.2	3.0
1998-01 0.25 ha	3.1	3.2	3.1	3.2

[1] : 1,600 kg in 1992-95, 1,350 kg in 1995-98 and 1,100 kg in 1998-01 ; [2] : lactations 2000-2001

32- Fertility

The average failure rate at first AI was close to 47.1 %.

No significant effect of the concentrate level, the part of grazed grass or of the forages sequences was identified, neither before, nor after the first AI. The risk of failure at 1st AI increased in case of previous metritis (odds ratio = 2.7), of high production at peak (OR = 1.6 for productions > 29 kg/d for the primiparous cows and > 37 kg/d for the multiparous cows).

33- Health disorders

Milk fevers were only studied on 533 lactations of cows of parity 3 or over. The average frequency reached 17.4 % on this population. The risk of developing a milk fever was decreased if the cow had previously received a mixed grazing/maize diet (OR = 0.2, vs a 100% grazing diet) during the dry period, and increased if its body condition score at calving was 3.25 (OR = 2.6 vs a score of 3.5 at calving).

The average frequency of post partum uterine disorders (retained placentas and /or metritis) reached 13.7%. The risk of post partum uterine disorders increased if the cow was delivered the following type of forage sequences during the dry period : "maize silage followed by grazing" or "grass silage followed by a mixed grazed grass/maize diet" (resp. OR = 5.1 and 3.8 versus a "grazed grass followed by a mixed grazing/maize diet"). The risk was also increased in case of abortion (OR = 3.5), twins (OR = 7.7), difficult calving (OR = 2.8), milk fever (OR = 1.7) and a retained placenta during the previous lactation (OR = 2.5). This risk appeared to be also linked to the body condition score at calving, the risk being increased for the extreme classes (OR = 2.1 and 2.2 for the following classes : bds <= 3.0 and >= 3.75 respectively).

The average frequency of metabolic disorders (ketosis, displaced abomasum and suspicions of such disorders treated by the stockmen) was 4.6 %. No impact of the concentrate level or of the part of grazed grass could be put to the fore. The risk of metabolic disorder was increased for the extreme classes of body condition scores at calving (OR = 2.6 and 2.7 for the following classes : <=2.75 and >=3.75 respectively).

The average frequency of clinical mastitis (first cases occurring in the lactation) reached 39.0 %. The risk of developing a mastitis was increased by a high production level at peak (OR = 1.6 for productions > 31 kg/d for the primiparous cows, and > 40.5 kg/d for multiparous cows), by the parity (OR = 1.5 and 2.3 for parities 2 and 3 and more respectively, compared to parity 1), and by the occurrence of a mastitis in the previous lactation (OR = 1.9).

The average frequency for lameness (first case of the lactation) was 21.3 %. As for mastitis, the risk of lameness increased in case of high production level at peak (OR = 1.9 for productions > 31 kg/d for primiparous cows, and > 40.5 kg/d for multiparous cows), of parity 3 or over (OR = 1.5), and in case of a lameness event during the previous year (OR = 1.8).

Altogether, the rate of lactations with at least one of those health events tended to be weaker for low concentrate levels ($P < 0.08$). The occurrence of health disorders reached 51.4% for the "300 kg/cow/year" group, 61.9% for the "650" group, and 66.4% for the control groups.

4- DISCUSSION

Over this 9 years period, the decrease in the concentrate level (within the frame of various parts of grazed grass) led to :

- an average decrease of 0.9 kg of milk per kg of saved concentrate, with a herd composed of 30 % of primiparous cows. According to several authors, the marginal efficiency of one kg of concentrate can vary from 0 to 1.4 (*Pflimlin et Morhain, 1988 ; Chenais, 1988 ; Gruber et al, 1991 ; Spiekers et al, 1991 ; Loeffler et al, 1996 ; Drochner et al, 1996*).
- a decrease in the true PC by 0.08 g/kg for 100 kg of saved concentrates, this decrease being probably related to the large amount of wheat delivered in the control groups (wheat being favourable to the PC). Most of the authors do agree about the decrease (or stagnation) of the PC in such cases (*Coulon et al, 1989 and previous references*).
- An increase in the FC by 0.25 g/kg for 100 kg of saved concentrates, probably linked to the higher fibrosity of the diet, and to a different orientation of the fermentation profiles in VFA related to the degradation products of the forages.
- The absence of any effect on the body condition score at calving, or on its post partum evolution.

Some of the modalities tested had to low absolute frequencies to facilitate the valorisation of the results (for instance : the body condition scores were quite homogenous in the herd, the extreme classes not being enough representative). Though the implementation of a low cost – low concentrate system clearly underlined :

- The total absence of impact on the failure rate at first AI, the bibliography being rich in variable and opposite results on this topic (*Chenais, 1988 ; Coulon et al, 1989 ; Marie et al, 1996 ; McGowan et al,* 1996 *; Horan et al, 2003*).
- No effect of the different concentrate levels or parts of grazed grass on the occurrence of health disorders (Horan et al, 2003 ; Pryce et al, 1999). Altogether, the low concentrate systems led to a lower rate of cows developing at least one health disorder than in the control groups, as underlined by *Fourichon et al (1999)* in her analysis of the occurrences of health disorders in various production systems, and by various authors in organic farming (*Weller and Cooper, 1996 ; Hardeng and Edge, 2001 ; Sehested et al, 2003*). In fact, the parity and the existence of previous health disorders in the cow's life appeared to be of greater importance than the composition of the diets.
- The protecting effect of feeding strategies including maize silage during the dry period to avoid milk fevers (they probably do limit the risk of Ca excess in diets based on ryegrass-white clover associations). Moreover, management strategies involving a feeding change during the dry period are frequently associated to the occurrence of retained placentas.
- The production peak, linked to the feeding management but also related to the genetic merit of the cow is closely associated to an increased risk of developing the following disorders: mastitis, lameness and failure at 1st AI, as already shown by Pryce et al (1999) for mastitis, or Heuer et al (1997) for the rate of failure at 1st AI.
- The body condition score at calving appeared to be associated to a higher risk of uterine disorders after calving, as well as metabolic disorders for its extreme values. *Erb et al* (1985) already described that cows that were too fat during the dry period were more frequently affected by reproduction disorders after calving, and by metritis if still fat 30 days pp. *Markusfeld et al (1990)* obtained the same results with multiparous cows with too low body condition scores at calving.

CONCLUSION

A large concentrate decrease can be achieved in dairy farms, even in case of high genetic merit herds. The consequences on dairy production of the type of feeding management implemented in Trévarez are now well known. The analysis of the reproduction and health data underlined that the global management of the groups and the forage basis of the diet near the disorders had little consequence on their occurrence. Moreover, the parity, the animal sanitary « history » as well as its dairy characteristics seemed to be of greater importance to explain the occurrence of health disorders than the feeding management it is submitted to. The keys for success in a low concentrate system seem then to be the following : the implementation of a well balanced diet, and the respect of the feeding transitions, whatever the type of diet in terms of forage basis.

Acknowledgements

The authors thank Arnaud Schmidt and William Araujo for their contribution to this study.

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