Dairy Production in Mountain:
farming systems, milk and cheese quality and implications for the future

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Evolution of milk calcium content during the year

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Abstract
The calcium content of milk from 2 breeds of dairy cows (Holstein and Normande) was observed during a complete lactation. The cows were reared in 2 feeding systems providing 2 levels of feeding: an intensive system based on corn silage and pasture supplemented with concentrate and a grass system based on preserved grass silage and pasture and no concentrate. Normande cows had higher milk calcium content than Holstein cows. There was no significant variation in total milk calcium content according to system of feeding over the whole lactation. However, in winter, calcium content was reduced in the “Grass system”. Milk calcium content evolved according to stage of lactation and season, with minimum milk calcium content usually occurring in May and June. The effect of season may be related to the maximum daily temperature and the duration of the day. In conclusion, many factors (nature of forage, breed, season…) seem to impact on milk calcium content.

Keywords: dairy cow breed, feeding, season, milk calcium

Introduction

Milk calcium content is a strongly heritable trait, which is related to milk protein and fat content (Alais, 1984). Calcium content is regarded as being relatively stable in cows’ milk during lactation. However, results from experimental and some commercial farms, have suggested that changes in milk calcium content can occur and relate in particular to changes in diets. The objective of this experiment was to compare the calcium content of milk from Holstein (Ho) and Normande (No) cows fed low input grass based systems or maize silage based systems.

Materials and methods

The experiment took place on the INRA experimental farm of Le Pin-au-Haras (Orne, France). A total of 60 dairy cows (34 multiparous and 26 primiparous), comprising 25 Ho and 35 No cows were observed from calving to drying off.

Table 1: Feeding systems during the year

Strategy	Expression of dairy potential	Autonomy – Low input
System	Intensive	Grass
Winter feeding (100 days)	Maize silage – Dehydrated alfalfa	Grass silage – Haylage
	30% concentrate	No concentrate
At grazing (from April to autumn)	0.35 ha /dairy cow	0.60 ha /dairy cow
Unsupplemented grazing period (days)	90	210
Additional forage	Maize silage (from July)	Grass silage (during dry weather)
Concentrate (kg DM/cow/day)	4	0

Two feeding systems were compared from January 2010 to January 2011. The **Intensive** system was designed to maximise individual performance, with a high energy diet fed during lactation. In the winter period, maize silage supplemented with 30% concentrate (12% wheat, 12% maize, 12% barley, 45% soybean meal, 11% beet pulp, 1% soya oil, 2.0% sugar cane molasses, 4% minerals, 1% salt) was fed. During the spring, summer and autumn periods, the Intensive system cows grazed pasture (0.35 ha/cow) supplemented with 4 kg/d of concentrate (21% wheat, 21% maize, 21% barley, 12% soybean meal, 21% beet pulp, 2% vegetable fat, 1% sugar cane molasses, 1% salt) and 250 g/d of minerals (Ca-P-Mg, 11-42-40) and were supplemented with maize silage from July (Table 1). The **Grass** system was designed to decrease inputs by feeding conserved grass in the form of silage (harvested by fine chop after wilting) or big bale silage (long, semi-wilted) and 300 g/d of minerals (Ca-P-Mg, 23-8-8) with no concentrate for the winter period. During spring, summer and autumn periods, cows in the Grass system grazed pasture (0.6 ha/cow) and had 500 g/d of minerals (Ca-P-Mg, 11-42-40) with no concentrate and were only supplemented with grass silage during dry weather (Table 1). In winter, cows were fed *ad libitum* with 10% of daily refusals. Eleven Ho and 18 No cows were allocated to the Intensive treatment and 14 Ho and 17 No cows were allocated to the Grass treatment. Individual milk yield was measured at each milking. Fat, protein and lactose contents were determined 3 times per week (i.e. on six milkings) by infrared analysis (Milkoscan, Foss Electric, Hillerød, Denmark). Once a month for the whole lactation, a detailed calcium analysis of milk samples was performed from a composite of evening and morning milkings. Total calcium was analysed by atomic spectrophotometry absorption on milk. Data were analysed using Proc Mixed procedure.

Results and discussion

No significant interaction was detected between feeding system and breed for milk yield and composition. During the whole lactation, the Grass treatment reduced milk yield (- 5.0 kg/d, P<0.001), with no significant effect on protein and total calcium contents. The No cows produced less milk (- 4.6 kg/d, P<0.001), but with a higher protein content (2.55 g/kg, P<0.001) and total calcium content (86.5 mg/kg, P<0.001) compared to Ho cows (Table 2).

Table 2: Effect of breed and feeding system on milk yield and composition during the whole lactation.

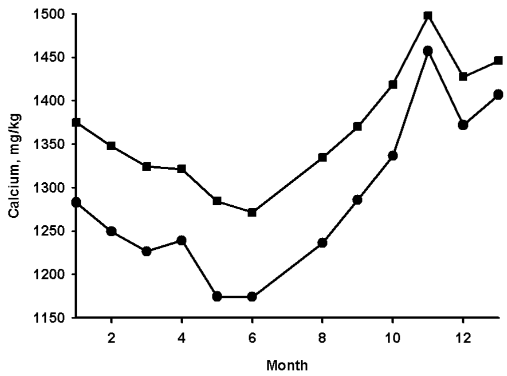
	Ho		No			Effect	
	Intensive	Grass	Intensive	Grass	SEM	Breed	Feeding
Milk yield, kg/d	26.6	20.9	21.3	17.0	3.51	**	**
Protein content, g/kg	32.9	31.6	35.0	34.6	2.58	**	ns
Total calcium, mg/kg	1297	1295	1384	1381	70.1	**	ns

During winter (January to March, 2010), the Grass treatment reduced milk yield, protein and total calcium contents (Table 3). During grazing period for all the cows, the Grass system only significantly reduced milk yield. According to Meschy (2010), calcium contained in conserved or fresh green forages is less available because it is in oxalate form. Moreover, calcium from hay (organic form) is less digestible than calcium from inorganic sources.

Table 3: Effect of breed and feeding system on milk yield and composition during winter and grazing period.

	Ho		No			Effect	
	Intensive	Grass	Intensive	Grass	SEM	Breed	Feeding
Winter							
Milk yield, kg/d	33.2	23.9	26.5	18.5	3.55	**	**
Protein content, g/kg	32.3	29.6	34.2	32.4	2.22	**	**
Total calcium, mg/kg	1303	1242	1403	1362	58.1	**	**
Grazing period (April to September)							
Milk yield, kg/d	28.4	22.3	23.2	18.9	3.05	**	**
Protein content, g/kg	33.2	32.0	35.2	35.0	1.98	**	ns
Total calcium, mg/kg	1224	1235	1325	1331	58.0	**	ns

Figure 1: Seasonal variation of milk calcium (corrected for the effect of lactation)(• Holstein cows, ■ Normande cows)



Milk calcium content changed during the year. It decreased from January to June and largely increased after July irrespective of breed. During May and June, milk from Ho cows, had a calcium concentration below the French legal limit of 1.2 g/L for consumption milk. There was a significant effect of stage of lactation on milk calcium content (not shown). At the beginning of lactation, colostrum had an elevated calcium content. After 2 months, the calcium content stabilised and increased at the end of lactation (Gaucheron, 2005).

When the data were corrected for stage of lactation, there was a significant effect of month (Figure 1). Month included numerous significant factors such as maximum daily temperature, day-length and radiance duration. When daily temperatures increase, cows increase respiratory rate causing alkalosis. When blood pH increases, the chemical groups on blood proteins release hydrogen ions, which combine with HCO_3 to form water and CO_2. As hydrogen ions leave the protein, their absence creates a negative charge that attracts free ionized Ca. As a result blood calcium can be reduced (Sanchez et al, 1994), and as a consequence, milk calcium.

Conclusions

The results of this study indicate that numerous factors (nature of forage, breed, season…) impact on milk calcium content. The biological mechanisms underlying these relationships require further investigation.

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