Effect of colostrum intake on diarrhoea incidence in new-born calves

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Abstract

In a survey which lasted one year and included data of 73 dairy cows with their calves, colostrum immunoglobulin G (IgG) of 22 primiparous cows and serum IgG of their calves were lower than the corresponding IgG levels of 51 multiparous cows and their calves. Serum IgG concentration was not correlated with diarrhoea incidence. Although there were no seasonal differences in the IgG concentration of colostrum and calf serum, neonatal diarrhoea incidence was higher in calves which were born in winter than in calves which were born in summer ($P < 0.01$). Thus the high diarrhoea incidence in winter was not a consequence of an insufficient IgG transfer to the calves.

The 60 calves of the second study were fed colostrum on the first day of life. From the second to the tenth day 28 experimental calves received milk and 0.5 l of surplus colostrum of the first and second milking twice a day, whereas 32 control calves received milk only twice a day. Two of the 28 experimental and 11 of the 32 control calves suffered from diarrhoea during the first ten days of life ($P < 0.05$). These results show that the ingestion of surplus colostrum in addition to milk after the first day of life protects the new-born calf against infectious diarrhoea.

Key words: calf – stored colostrum – diarrhoea, immunoglobulin G

Einfluss der Kolostrumaufnahme auf die Durchfallinzidenz neugeborener Kälber

Im Verlaufe eines Jahres wurde der Gehalt an Immunglobulin G (IgG) im Kolostrum von 73 Milchkühen und im Serum der neugeborenen Kälber nach Aufnahme einer definierten Menge Kolostrum untersucht. Die primiparen Kühe und ihre Kälber hatten Kolostrum bzw. Serum mit einer tieferen IgG-Konzentration als multipare Kühe und ihre Kälber. Es bestand keine Beziehung zwischen dem IgG-Gehalt im Serum und der Durchfallhäufigkeit der Kälber. Obwohl keine saisonalen Unterschiede im IgG-Gehalt des Kälberserums festgestellt wurden, litten die im Winterhalbjahr geborenen Kälber häufiger an Durchfall als die im Sommerhalbjahr geborenen Kälber ($P < 0.01$). Das gehäufte Auftreten von Diarrhoe im Winter war somit nicht die Folge eines ungenügenden Immunglobulinstatus der Kälber.

In einer anschliessenden Untersuchung erhielten 60 neugeborene Kälber am ersten Lebenstag Kolostrum. Davon erhielten 28 Versuchskälber vom zweiten bis zum zehnten Lebenstag täglich zwei mal Milch plus einen halben Liter überschüssiges Kolostrum. 32 Kontrollkälber erhielten kein überschüssiges Kolostrum, wurden aber sonst gleich wie die Versuchskälber gefüttert. Zwei der 28 Versuchskälber und 11 der 32 Kontrollkälber erkrankten an Durchfall ($P < 0.05$). Die Aufnahme kleiner Mengen Kolostrum in den ersten zehn Lebenstagen kann das Kalb gegen Durchfallerkrankungen schützen.

Schlüsselwörter: Kalb – gelagertes Kolostrum – Durchfall – Immunoglobulin G

Introduction

Diarrhoea is a common disease of new-born calves. Rotavirus, coronavirus and *Cryptosporidium parvum* are frequently detected in the faeces of affected animals and are considered to play an important aetiological role. In Switzerland diarrhoea prevalence is higher in the cold season than in the vegetation period (April to October). Seasonal variation in blood serum immunoglobulin levels of new-born calves with highest levels in the warm season has been described (Gay et al., 1983; Fallon and Harte, 1987; Burton et al., 1989). This finding suggests that calves which are born in the cold

season may be more susceptible to infectious diseases because they have low serum levels of maternal antibodies. In a survey lasting one year the hypothesis was tested that winter-born calves have low serum concentrations of maternal antibodies which predispose them to neonatal diarrhoea.
In a subsequent feeding trial the hypothesis was tested that adding surplus colostrum to the milk fed after the first day of life provides the calf with immunoglobulins which are not absorbed but remain in the lumen of the gastrointestinal tract and protect the calf from infectious diarrhoea.

Animals, material and methods

Dairy cows and new-born calves of the Swiss federal research station belonging to the Simmental – Red Holstein, Swiss Brown and Holstein Friesian breeds were used for our investigations. Between April and October, the cows were on pasture and entered the stable only to be milked and for calving. Between November and March they were kept in the stable. They were not vaccinated against agents causing calf diarrhoea. The calves were separated from their dams immediately after birth and put into clean individual wooden pens located in the cows' stable where they remained for the first ten days of life. As a rule they received colostrum of the 1st milking within six hours after birth and colostrum of the second milking eight to twelve hours later in buckets with nipple feeders. 1.5 l of colostrum per meal were offered to calves weighing up to 40 kg. Heavier calves received an additional 0.2 l per 5 kg of additional body weight. The calves received milk of their dams twice a day from the second to the tenth day of life. Four litres per day were offered between the second and the fourth day, and from the fifth to the tenth day the calves received 6 litres per day. Colostrum and milk intake, body weight at birth and at ten days and the occurrence of diarrhoea within the first ten days of life were recorded. Calves with diarrhoea were treated with an oral rehydrating solution containing electrolytes, glucose and glycine.

Survey

For this study 22 primiparous and 51 multiparous cows with their calves which were born within one year were used. Colostrum samples of the first and second milking were obtained, and blood was collected from the calves when they were between two and four days old. After incubation with added rennet, colostrum samples were centrifuged to obtain colostrum whey, which represented on an average 90% of colostrum volume. Colostrum whey and blood serum samples were stored at –20°C until analysed. Immunoglobulin G (IgG) was analysed by radial immunodiffusion (RID kit, Bindingsite, Birmingham, GB) in colostrum whey and serum samples. Assuming that blood serum represented 7% of body weight, the ratio of serum IgG to ingested IgG (intake from the first and second colostrum) was calculated to estimate the efficiency of absorption of IgG in the calves, as described by Quigley and Drewry (1998). IgG serum levels in new-born calves of less than 8 g/l were considered insufficient (Perino et al., 1993). Data obtained during the cold season (November to March) were compared with data obtained during the vegetation period (April to October). Moreover data obtained from primiparous cows and their calves were compared with those of multiparous cows and their calves.

Feeding trial

60 calves born between November and April of two consecutive years were used to examine the effect of surplus colostrum on diarrhoea incidence. Ten litres of surplus colostrum from the first and second milking were collected in large plastic bottles, and 80 ml of a 10% solution of propionic acid per litre was added to prevent spoilage. Surplus colostrum was stored in the stable at an ambient temperature of about 15° C and was fed within ten days after collection. The new-born calves were randomly assigned to either the experimental group or to the control group. On the first day of life, calves of both groups received colostrum of the first and second milking. From the second to the tenth day, 28 experimental calves received a diet consisting of milk and of 0.5 l of their dam's surplus colostrum twice a day, whereas 32 control calves received a diet consisting of milk only twice a day. The volume fed per meal was identical in both groups. Since it could not be excluded that propionic acid which was used to preserve surplus colostrum might have antidiarrhoeal activity, 40 ml of a 10% solution of propionic acid was added to each meal of the control animals in order to administer equal amounts of propionic acid to the calves of both groups. As the results of the first year showed that propionic acid did not protect against diarrhoea, no propionic acid was added to the control diet in the second year. Samples from 10 batches of surplus colostrum were obtained for IgG and vitamin analyses on the day of colostrum collection and again after 10 days of storage at 15° C. IgG was analysed in the colostrum whey using the RID method, whereas the fat soluble vitamins A, E and β-carotene were analysed in whole colostrum using high pressure liquid chromatography

Table 1: Seasonal effects on immunoglobulin G concentrations in colostrum and calf serum, diarrhoea incidence and growth (mean± SD).

	April–October (n=28)	November–March (n=45)	P-Value
Multiparous / primiparous cows (n)	19/9	32/13	0.80
Number of calves	29	46	
Calf birth weight (kg)	45±6	46±6	0.25
Weight gain first 10 days (kg)	8.0±2.0	4.6±2.5	<0.01
Number of calves with diarrhoea	0	19 (= 41%)	<0.01
IgG concentration 1st colostrum (g/l)[1]	62±30	65±31	0.53
IgG concentration 2nd colostrum (g/l)[1]	33±21	32±16	0.92
IgG concentration in calf serum[2] (g/l)	14±7	14±6	0.96
Efficiency of IgG absorption (%)	31±14	29±12	0.55
Number of calves with serum IgG concentration <8 g/l (%)	6 (=21%)	9 (=20%)	1.00

[1] in colostrum whey
[2] Blood was collected between the 2nd and 4th day of life

(HPLC) method. Faecal samples of two experimental and of nine control calves which suffered from diarrhoea were analysed for enteropathogenic *E. coli,* rota- and coronavirus and *Cryptosporidium.*

Statistical analysis

Normally distributed data were described by means and standard deviations and were tested for differences with analysis of variance. Frequencies were compared with two-tailed Fisher's exact test. Differences with a probability of error <5 % ($P < 0.05$) were considered statistically significant.

Results

Survey

Between November and March, more than a third of the new-born calves had acute diarrhoea within the first ten days of life, whereas no case of diarrhoea occurred between April and October (Tab. 1). The winter-born calves gained significantly ($P<0.01$) less weight than the summer-born calves (Tab. 1). IgG levels in colostrum and calf serum, efficiency of IgG absorption and the percentage of calves with insufficient serum IgG levels did not significantly differ between the two periods (Tab. 1). In comparison with multiparous cows and their calves, primiparous cows produced colostrum with lower IgG concentrations ($P<0.01$), their calves had lower serum IgG levels ($P<0.01$) and the percentage of calves with insufficient serum IgG levels was higher ($P<0.01$), whereas IgG absorption efficiency was not reduced (Tab. 2). Diarrhoea incidence did not differ ($P = 0.89$) between groups of calves with adequate and insufficient serum IgG levels. None of the calves died within the first ten days of life.

Feeding trial

After 10 days of storage at 15° C, surplus colostrum still contained most of its initial amount of IgG and vitamin A and about 60% of its initial amount of β-carotene and vitamin E (Tab. 3). In the first year two of the 17 experimental calves and eight of the 18 control calves suffered from diarrhoea,

Table 2: Effect of parity on Ig G concentrations in colostrum and calf serum (mean± SD).

Ig G concentration (g/l)	Primparous cows (n=22)	Multiparous cows (n=51)	P-Value
Colostrum, 1st milking[1]	49±21	71± 31	<0.01
Colostrum, 2nd milking[1]	25±18	37±31	<0.01
Calf serum[2]	9±4	16±6	<0.01
Efficiency of IgG absorption (%)	28±16	31±12	0.36
Number of calves with serum IgG concentration <8 g / l (%)	10 (= 45%)	5 (=9%)	<0.01

[1] in colostrum whey
[2] Blood was collected between the 2nd and 4th day of life

Table 3: Effect of storage (10 days, 15°C) on IgG and vitamin levels of preserved surplus colostrum (mean ± SD).

Colostrum	IgG (g/l)[1]	Vitamin A (mg/l)[2]	β-carotene (mg/l)[2]	Vitamin E (mg/l)[2]
Fresh	61 ± 18	2.0 ± 1.8	1.3 ± 0.6	3.2 ± 1.8
Stored	55 ± 18	1.7 ± 2.1	0.8 ± 0.8	2.0 ± 2.6

[1] in colostrum whey
[2] in whole colostrum

Table 4: Effect of surplus colostrum consumption on diarrhoea incidence and weight gain (mean ± SD).

Group	Experimental (n = 28)	Control (n = 32)	P-Value
Diarrhoea/healthy (n)	2 / 26	11 / 21	< 0.05
Incidence (%)	7	34	
Birth weight (kg)	45 ± 5	43 ± 6	0.24
Weight gain first 10 days (kg)	7.2 ± 2.0	6.2 ± 1.9	< 0.05

whereas in the second year none of the eleven experimental calves and three of the 14 controls had diarrhoea. Altogether two of the 28 experimental animals (7%) and 11 of the 32 control animals (34%) suffered from diarrhoea ($P < 0.05$, Tab. 4). Most cases of diarrhoea occurred between the fourth and the tenth day of life. Weight gain was significantly ($P < 0.05$) higher in the experimental group than in the control group (Tab. 4). None of the calves died within the first ten days of life.

Eleven faecal samples which were collected from experimental and control calves with diarrhoea were negative for rotavirus and enteropathogenic *E. coli*. Nine samples were positive for *Cryptosporidium* and three were positive for coronavirus (both pathogens were found in one sample).

Discussion

The fact that in the survey no effect of season on colostrum and calf serum IgG levels was observed is in agreement with Pritchett et al. (1991) who found that season of calving did not significantly influence colostral IgG concentration, but is in contrast to the findings of Gay et al. (1983), Fallon and Harte (1987) and Burton et al. (1989) who described seasonal variation in blood serum immunoglobulin levels of new-born calves. Thus, the survey does not confirm our initial hypothesis that the high diarrhoea incidence in winter is a consequence of low levels of maternal antibodies in new-born calves. Donovan et al. (1986) hypothesized that low serum immunoglobulin levels in new-born calves are correlated with either extremely low or high ambient temperature. If this hypothesis is true the winter period is therefore unlikely to affect the transfer of maternal immunoglobulins to calves which are born in insulated stables, the most common type of housing for cows in Switzerland. The high diarrhoea incidence in new-born calves which is seen during the winter months in Switzerland is mainly due to an increased infection pressure, since cows are permanently kept in stables and since most calves are born during this period of the year. The fact that rota- and coronavirus excretion by cows occurs more frequently during winter than during summer (Collins et al., 1987; Kodituwakku and Harbour, 1990) will contribute to the contamination of the stable.

Colostrum produced by many primiparous cows did not contain sufficient IgG concentrations to provide their calves with the recommended minimum amount of 80–100 g colostral IgG (Radostits et al., 2000). Poor quality colostrum of primiparous cows was responsible for the low serum IgG levels of their calves since these calves absorbed colostral IgG as efficiently as calves of multiparous cows. Feeding colostrum of multiparous cows to new-born calves of primiparous cows could therefore improve their immunoglobulin status.

The results of our survey show that high blood serum levels of maternal antibodies are of minor importance for the protection against diarrhoea caused by viruses and cryptosporidia and agree with those of Donovan et al. (1998) who found that low serum immunoglobulin levels in new-born calves are a significant risk factor for septicemia and pneumonia, but not for diarrhoea.

Results of the feeding trial with surplus colostrum agree with reports (Snodgrass et al., 1982; Castrucci et al., 1984; Saif and Smith, 1985) showing that immunoglobulins have to be present in the gut in order to protect calves from viral enteritis. Studies (Fayer et al., 1989; Harp et al., 1989) about the protective effect of cow colostrum against cryptosporidiosis in calves are contradictory. In the trials mentioned above where prolonged colostrum feeding had a protective effect against infectious enteritis, frozen colostrum of vaccinated cows was used and the calves were subjected to a challenge infection with the pathogen used to vaccinate the

cows. Our results show that under farm conditions where it is impractical to freeze large amounts of surplus colostrum and to thaw small portions for each meal, surplus colostrum can be preserved for up to ten days with propionic acid without appreciable loss of IgG and can be used to prevent diarrhoea in new-born calves. The fact that a high percentage of control animals which received milk with propionic acid had diarrhoea demonstrates that the reduced incidence of diarrhoea in the experimental animals was not due to propionic acid but rather to the immunoglobulin content of surplus colostrum. Other substances such as growth factors which occur in much higher concentrations in colostrum than in mature milk (Blum and Hammon, 2000) may also contribute to its positive effect on the health of new-born animals. Surplus colostrum can be regarded as an alternative to commercially available immunoglobulin supplements containing colostrum or egg yolk antibodies (Erhard et al., 1993), recommended as feed supplements for diarrhoea prevention. Besides the fact of being available when needed, colostrum produced by cows living on the farm has the additional advantage of containing antibodies against the pathogens which are actually present in the herd. Nevertheless, the efficacy of surplus colostrum against infectious diarrhoea could most likely be improved if pregnant cows were vaccinated against viral enteropathogens.

Effets de l'ingestion de colostrum sur l'incidence de diarrhées du veau nouveau-né

La concentration d'immunoglobuline G (IgG) fut déterminé dans le colostrum de la 1ère et la 2ème traite de 51 vaches multipares et de 22 vaches primipares de races laitières qui avaient vêlé au courant d'une année ainsi que dans le sang de leurs veaux qui avaient reçu des quantités déterminées de colostrum de leurs mères. Les vaches primipares et leurs veaux avaient des taux d'IgG moins élevés que les vaches multipares et leurs veaux. Il n'y avait pas de rapport entre la concentration sanguine en IgG et l'incidence de diarrhée chez les veaux nouveau-nés. Le taux d'IgG ne variait pas selon les saisons; l'incidence de diarrhée était cependant plus élevée pendant la période hivernale que pendant la période estivale ($P < 0.01$). Les diarrhées observées en hiver n'étaient pas la conséquence d'un apport insuffisant d'immunoglobulines. Les 60 veaux de l'essai suivant reçurent du colostrum durant le premier jour de vie. Du deuxième au dixième jour de vie, les 28 veaux expérimentaux reçurent deux fois par jour du lait plus 0.5 l de colostrum excédentaire tandis que les 32 veaux témoins reçurent exclusivement du lait. Le nombre de veaux qui avait la diarrhée était plus bas dans le groupe expérimental que dans le groupe témoin (deux sur 28 comparé à 11 sur 32; $P < 0.05$). L'essai montre que l'ingestion de petites quantité de colostrum excédentaire pendant les premiers dix jours de vie protège les veaux contre la diarrhée.

L'effetto dell'ingerimento di colostro sull'incidenza di diarree di vitelli neonati.

Nel corso di un anno, è stato ricercato in un rilievo il contenuto d'IgG nel colostro di 51 vacche e 22 manze, e nel siero di vitelli neonati, dopo l'ingerimento di una determinata quantita' di colostro.
Le manze ed i loro vitelli avevano il colostro e rispettivamente il siero con una concentrazione piu' bassa d'IgG, che le vacche ed i loro vitelli. Non c'era una relazione fra il contenuto d'IgG nel siero e la predisposizione alla diarrea di vitelli. Pur non essendoci una differenza stagionale nel contenuto d'IgG nel siero dei vitelli, i vitelli nati nel periodo invernale sono cresciuti nettamente piu' lenti e hanno sofferto nettamente piu' spesso di diarree, che i vitelli nati nel periodo estivo ($P < 0.01$). In una seguente ricerca, i 60 vitelli neonati hanno ricevuto il primo giorno di vita colostro. I 28 vitelli sperimentali hanno ricevuto dal secondo fino al decimo giorno di vita due pasti composti da latte e mezzo litro di colostro in eccesso della loro madre. I 32 vitelli di controllo non hanno ricevuto del colostro in eccesso, ma altrimenti sono stati nutriti come i vitelli sperimentali. Due dei 28 vitelli sperimentali e 11 dei 32 vitelli di controllo si sono ammalati di diarrea ($p < 0{,}05$). Il risultato dimostra che l'ingerimento di piccole quantita' di colostro nei primi 10 giorni di vita ha un effetto protettivo contro la diarrea.

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Received for publication: 22 September 2000
Accepted in the present form: 5 November 2001