Blood glucose level and cross-sucking behaviour by different rearing systems in group housed calves

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Summary

Calves in group housing systems with artificial milk feeding often show cross-sucking behaviour, which can result in illness and economical losses. Reasons are not clearly defined up to now, but a low blood glucose level is suspected to be one reason for cross-sucking activity of group housed calves. Our experiment investigated the influence of the amount of milk intake (restrictive or ad libitum) and different techniques of milk intake (natural or at the automatic teat feeder and with or without fixation in the feeding stall) in relation to blood glucose level and cross-sucking behaviour and was carried out with 120 calves (German Holstein) in twelve treatments. In dependence of the respective treatment the calves were fed with whole milk or milk replacer.

The data acquisition of the cross-sucking behaviour was performed by direct observation within an age group of calves between 39 to 58 days. At the age of 50 to 65 days blood samples were taken of the calves to obtain their blood glucose profile. In the 15 min period after finishing the milk meal calves show cross-sucking behaviour, which is related to milk intake. In this period eleven treatments showed an increase in blood glucose between 0.650 to 2.060 mmol/l with values between 5.670 and 9.160 mmol/l. In this 15 min period there was no cross-sucking within the natural milk intake. Most calves (5 to 8) with cross-sucking behaviour were from the treatment feeding stall without fixation.

Keywords: Dairy calves, organic farming, group-housing, blood glucose level, cross-sucking

Zusammenfassung

Blutglukosekonzentration und gegenseitiges Besaugen von Kälbern in Gruppenhaltung in Abhängigkeit verschiedener Aufzuchtverfahren

Bei mutterlosen Aufzuchtverfahren von Kälbern in Gruppen ist während der Tränkeperiode gegenseitiges Besaugen zu beobachten, wodurch Erkrankungen und finanzielle Verluste auftreten können. Die genaue Ursache dafür ist bislang nicht eindeutig geklärt, ein niedriger Blutglukosespiegel wird neben anderen Faktoren aber als Ursache vermutet.

Im Versuch wurde der Einfluss eines unterschiedlichen Angebots an Milchmenge (restriktiv oder ad libitum) und einer unterschiedlichen Technik bei der Milchaufnahme (natürlich oder am Tränkeautomaten sowie mit oder ohne Fixierung im Tränkestand) auf den Blutglukosespiegel und das gegenseitige Besaugen bei 120 Kälbern (deutsche Holstein) in zwölf Varianten untersucht. Die Kälber haben je nach Variante Frischmilch oder Milchaustauscher erhalten.

Die Datenaufnahme zum gegenseitigen Besaugen erfolgte mit Direktbeobachtungen im Alter von 39 bis 58 Tagen und die Blutprobennahmen zur Erstellung von Glukoseprofilen im Alter von 50 bis 65 Tagen. Innerhalb der ersten 15 min nach der Milchaufnahme zeigen die Kälber das gegenseitige Besaugen, das mit der Milchaufnahme in Verbindung steht. In diesem Zeitraum war bei elf Varianten ein Zuwachs der Glukosewerte zwischen 0,650 und 2,060 mmol/l zu verzeichnen mit Werten von 5,670 und 9,160 mmol/l. Gegenseitiges Besaugen ist in diesem Zeitraum bei der natürlichen Milchaufnahme nicht aufgetreten, hingegen haben 5 bis 8 Kälber bei einer Variante im Tränkestand ohne Fixierung gegenseitiges Besaugen gezeigt.

Schlüsselwörter: Kälbergruppenhaltung, Ökologischer Landbau, Blutglukoseniveau, gegenseitiges Besaugen

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1 Introduction

Milk feeding of calves can be done artificially with a bucket, a bucket with teats, automatic teat feeders or naturally by suckler- or foster-cows. Artificially reared calves housed in groups often show cross-sucking behaviour, which rarely occurs in group housed calves fed by their mothers or foster cows.

Organic dairy farmers are obliged to house calves in groups, starting in the second week of their life. One major disadvantage of group housing calves is the occurrence of cross-sucking as an abnormal behaviour.

Preferred parts of the body for cross-sucking are scrotum and prepuce as well as udder area, navel and ears (Sambraus, 1985). Cross-sucking may lead to inflammatory diseases of navel and ears, bezoars and defects of the udder. Unsatisfied sucking activity is mentioned as one major reason for cross-sucking with artificially reared calves. Calves reared by their mothers suck approximately 6 times per day within the first 3 months with a mean duration of 10 minutes (Sambraus, 1985). Bucket fed calves need 2 to 3 minutes per milk meal (Sambraus, 1985), which corresponds to the duration of a milk meal with the automatic teat feeder of less than 3 minutes (Ferrante et al., 1991). There is thus a lack of sucking activity, increasing the motivation for cross-sucking (Sambraus, 1985; Lidfors, 1993) lasting approximately the same time as a natural milk meal does (Sambraus, 1985). The intensity of cross-sucking after the milk meal decreases within 20 to 30 minutes (Graf et al., 1989; Lidfors, 1993) or within 10 minutes (de Passillé et al., 1992).

Much research was done to reduce cross-sucking in calves. A reduction or interruption of milk flow leads to a longer duration of milk intake (de Passillé, 2001), but does not affect cross-sucking (Jensen and Holm, 2003). Higher milk intake and more but smaller milk meals per day could reduce cross-sucking (Brummer, 2004). An addition of 2 g of glucose per litre milk or milk replacer could reduce cross-sucking as well (Egle et al., 2004). Further solutions for the reduction of cross-sucking are self-locking feed stalls (Weber, 1998; Brummer, 2004), fixing calves with head locks after the milk meal (Maity and Tomer, 1998) or the presence of (sealed) artificial teats (de Passillé, 2001). Also enriched feeding areas (Keil et al., 2001) or the offer of straw, concentrates or hay reduced the cross-sucking behaviour (Kitter and Kurz, 1967; Roth et al., 2004; Phillips, 2004).

The literature shows the influence of the feeding and rearing systems on the cross-sucking behaviour.

2 Material and Methods

The experiment was carried out from 09/05 up to 04/06 and from 09/06 to 03/07 and investigated the **influence of different levels of milk intake** and different **milk feeding techniques** affecting blood glucose level and cross-sucking behaviour.

Twelve treatments were investigated. In two treatments calves stalled up in a two floor system with deep litter (lying area with straw bedding) and feeding area (concrete floor with chipped wood). In the other 10 treatments calves had an exercise yard (bark mulch). In addition in two treatments there was a furnished post feeding area (concrete floor with chipped wood).

The lying area measured 2.7 m² per calf, the feeding area was 1.2 m² per calf with access to the post feeding area and 0.9 m² per calf without access to the post feeding area. Treatments with an exercise yard had an area with 8.1 m² or 13.2 m² per calf.

In the treatments with post feeding area the calf could enter the post feeding area only after finishing a milk meal. A new feeding stall with automatic gates was attached to an automatic teat feeder. One gate opened sidewards into an enriched area immediately after the milk intake was finished. In that protected area calves could use three sealed rubber teats fixed at a bucket. In one treatment a net filled with a straw bale was hung up at the truss. A simple gate was used as a one-way exit back to the feeding area. Calves without a milk meal left the feeding stall backwards (Figure1).

Figure. 1:
Feeding stall and post feeding area

The Foerster Company from Germany allocated the automatic feeder "stand alone 2000". The artificial teats had sensor elements to measure tongue temperature as an estimate for body core temperature. In order to protect the sensing system against the calves biting, the teats were automatically covered with a metal sheet after the milk meal. The calves of ten treatments were fed by this automatic teat feeder.

The experiment was carried out with 120 male and female calves (German Holstein) from one origin (FAL herd Brunswick). In the respective treatments the calves got whole milk or milk replacer. The restrictive feeding plan was about 65 d. In the beginning the calves got 6 to 7 litres; this amount was reduced from day 20th to day 35th to 3 litres. In other treatments the calves got more milk (see detail of the treatments, Table 1).

The milk replacer of the Nordmilch Company, Zeven ("BoviNormASS") consists of 22.5 % crude protein and 15.0 % crude fat.

The different treatments were characterized as follows (Table 1):

The treatment **"whole milk"** (item 1) with an exercise yard got whole milk from the automatic teat feeder and had the feeding plan for a restrictive rearing period. The feeding stall had automatic doors without access to the post feeding area.

Within the beginning of the experiment the calves of treatments **"cow-calf-I"** (item 2) and **"cow calf-II"** (item 7) with an exercise yard could suckle two times per day at their mother or foster cow, and later one time per day. The cows had access to their calves for 30 minutes per meal and went to the milking parlour after the milk meal of the calves. The calves were weighed before and after suckling in order to measure the amount of milk intake. The duration of milk intake per udder quarter was determined by direct observation. There was no difference between cow-calf-I and cow-calf-II; we repeated this treatment as a control group in both years.

The calves of the treatment **"milk replacer"** (item 3) and exercise yard got milk replacer with the automatic teat feeder and had a feeding plan for a restrictive rearing period. The feeding stall had automatic doors without access to the post feeding area.

The group **"post feeding area"** (item 4) and exercise yard got milk replacer from the automatic teat feeder and had a feeding plan for a restrictive rearing period. The feeding stall had automatic doors and the calves had access to the post feeding area. The post feeding area was equipped with three sealed rubber teats fixed onto a bucket and a net filled with a straw bale was hung up at the truss.

The treatment **"diameter"** (item 5) and exercise yard got milk replacer from the automatic teat feeder and had a feeding plan for a restrictive rearing period. Directly before the teat, a small metal canal reduced the diameter of the milking tube from 6 mm to 2 mm. The feeding stall had automatic doors without access to the post feeding area.

The **"glucose group"** (item 6) with exercise yard got milk replacer from the automatic teat feeder and had a

Table. 1:
Basic data of the study

treatment	item	milk treatment	add on 2 g glucose per litre	diameter milking tube [mm]	housing system	entry post feeding area	feeding stall system
"whole milk"	1	whole milk	no	6	with excercise yard	no	automatic doors
"cow-calf-I"	2	whole milk cow/ foster cow	no	-	with excercise yard	no	without feeding stall
"milk replacer"	3	milk replacer	no	6	with excercise yard	no	automatic doors
"post feeding area"	4	milk replacer	no	6	with excercise yard	yes	automatic doors
"diameter"	5	milk replacer	no	2	with excercise yard	no	automatic doors
"glucose"	6	milk replacer	yes	6	with excercise yard	no	automatic doors
"cow-calf-II"	7	whole milk cow/ foster cow	no	-	with excercise yard	no	without feeding stall
"ad lib whole milk"	8	whole milk	no	6	with excercise yard	no	automatic doors
"open feeding stall"	9	milk replacer	no	6	two-floor	no	without a door
"glucose and post feeding area"	10	milk replacer	yes	6	with excercise yard	yes	automatic doors
"ad lib milk replacer"	11	milk replacer	no	6	with excercise yard	no	automatic door
"fixation"	12	milk replacer	no	6	two-floor	no	automatic door with fixation

feeding plan for a restrictive rearing period. The feeding stall had automatic doors without access to the post feeding area. Two grams of glucose were added to each kg of mixed milk replacer.

The **"ad libitum groups"** with exercise yard got milk replacer (item 11) or whole milk (item 8) from the automatic teat feeder. At the beginning of the rearing period they got 15 litres milk divided into three meals per day and later 10.0 litres milk in one milk meal per day. The feeding stall had automatic doors without access to the post feeding area.

The calves of the treatment feeding stall without a door (**"open feeding stall";** item 9) and a two floor-system without exercise yard got milk replacer from the automatic teat feeder with a feeding plan for a restrictive rearing period. The **"post feeding area group with glucose"** (item 10) and exercise yard got milk replacer and 2 g glucose per litre from the automatic teat feeder and had a feeding plan for a restrictive rearing period. The calves left the feeding stall sidewise into the post feeding area equipped with three sealed rubber teats fixed to a bucket.

The calves of the treatment "**fixation**" (item 12) with a two floor-system without exercise yard got milk replacer from the automatic teat feeder and had a feeding plan for a restrictive rearing period. The feeding stall had a door, which closed for 10 min after the beginning of the milk meal.

The data acquisition of the cross-sucking behaviour was carried out by direct observation within an age group of calves between 39 to 58 days. The objects of the observation were the duration of the milk intake and cross-sucking behaviour; the observation took place over three days at the same time: In all treatments with feeding by the automatic teat feeder the calves had access to their milk at 5 p. m. The calves of the cow-calf-groups got their only milk meal per day at 2.30 p. m. The observation started at the beginning of the milk intake and finished 20 minutes after the end of the milk meal.

At the age of 50 to 65 days all calves in all treatments were bled to obtain their blood glucose profile. All calves were bled seven times on the sampling day. The first sample was taken between two and three hours before the milk intake, the second directly before milk intake, the third directly after finishing the milk meal and the forth to seventh, 7:30 min, 15 min 1 hour, 2 hours respectively after finishing the milk meal. In addition data of the calf feeder and from the video observation were collected.

All data were transferred into Excel sheets. The data were tested by statistic package SAS (9.1).

Negative tests of normality indicated the use of non-parametric procedures (H test, U test).

The Mann–Whitney U test was used as a non-parametric test for assessing whether two independent samples of observations come from the same distribution.For the comparison of more than two independent samples the Kruskal-Wallis H test was conducted.

3 Results

In those treatments with a restrictive drinking plan the milk intake was limited to 3.0 litres per calf during the direct observation. The mean amount of milk in the cow-calf-groups was between 8.0 to 8.5 l, in the ad libitum milk replacer group 7.4 l and in the ad libitum whole milk group 9.2 l (Table 2).

The duration of milk intake in those treatments with a restrictive drinking plan ranged between 03:50 min and 05:25 min. The cow-calf-groups showed durations between 10:44 min and 11:11 min, and the ad libitum groups 14:01 min and 15:29 min (Table 2). The milk flow (l/min) was highest for the treatment whole milk with 1.130 l/min. The ad libitum whole milk group had a milk flow of 1.060 l/min and the milk replacer group of 0.962 l/min. The ad libitum milk replacer group had 0.952 l/min and the treatment without door 0.946 l/min. The lowest milk flow was found in the treatments fixation with 0.799 l/min and the cow-calf-II with 0.727 l/min (Table 2).

Table. 2:

Median of amount of milk, duration of milk meal and milk flow

treatment	item	mean of		
		amount of milk [l]	duration of milk intake [mm:ss]	suckling speed [l/m]
"whole milk"	1	3.0	3:50	1.130
"cow-calf-I"	2	8.0	14:01	0.842
"milk replacer"	3	3.0	4:30	0.962
"post feeding area"	4	3.0	5:00	0.865
"diameter"	5	3.0	5:15	0.824
"glucose"	6	3.0	4:54	0.882
"cow-calf-II"	7	8.5	15:29	0.727
"ad lib whole milk"	8	9.2	11:11	1.060
"open feeding stall"	9	3.0	5:25	0.946
"glucose and post feeding area"	10	3.0	5:06	0.861
"ad lib milk replacer"	11	7.4	10:44	0.952
"fixation"	12	3.0	4:34	0.799
H-Test		***	***	***

Lower blood glucose levels were found between two and three hours before milk intake in the treatments post feeding area with 4.605 mmol/l and post feeding area with glucose with 4.910 mmol/l. The highest levels were found in the cow-calf-group-II with 6.670 mmol/l and

the ad libitum groups with values between 6.235 mmol/l and 6.205 mmol/l. The values of blood glucose were constant between the first sample and the third sample and showed values between 4.430 mmol/l and 5.945 mmol/l. The treatment ad libitum whole milk and the cow-calf-groups increased from 6.205 mmol/l and 6.670 mmol/l up to 6.830 mmol/l and 8.340 mmol/l. The exception was the ad libitum milk replacer group with constantly decreasing values from 6.195 mmol/l to 5.677 mmol/l and an increase to 6.205 mmol/l (Table 3).

Table. 3:
Median of blood glucose profiles

item	point in time				
	Basal sample 2-3 h before milk intake [mmol/l]	directly before milk intake [mmol/l]	directly after finishing milk intake [mmol/l]	7:30 m after finishing milk intake [mmol/l]	15 m after finishing milk intake [mmol/l]
1	5.320	4.915	5.020	4.950	5.670
2	6.335	6.115	7.045	7.160	8.010
3	5.395	5.230	5.170	5.255	6.555
4	4.605	4.460	4.430	4.790	5.990
5	5.440	5.295	5.245	5.810	6.440
6	5.470	5.400	5.375	5.960	6.590
7	6.670	6.585	8.340	8.780	9.160
8	6.235	5.950	6.830	7.850	8.585
9	5.945	5.960	5.660	6.055	6.790
10	4.910	4.910	4.970	4.580	4.710
11	6.205	5.655	6.195	7.430	8.255
12	5.855	5.490	5.355	5.375	6.350
H test	***	***	***	***	***

In the 15 min period after finishing the milk meal the calves showed cross-sucking behaviour, which is related to milk intake. In this period eleven treatments had an increase in blood glucose. The increase was between 0.650 mmol/l to 2.060 mmol/l with values between 5.670 mmol/l and 9.160 mmol/l. The highest increase resulted from the treatments milk replacer, post feeding area and ad libitum whole milk. The value of the ad libitum increased by 2.060 mmol/l and had a value of 8.255 mol/l. The lowest values 7:30 min after finishing the milk meals were found in the post feeding area with glucose at 4.580 mmol/l and 15 min later at 4.710 mmol/l. The post feeding group and whole milk group showed values of 4.790 mmol/l and 4.950 mmol/l with an increase to 4.790 mmol/l and 5.990 mmol/l. The treatments milk replacer, diameter, glucose, feeding stall without door and fixation showed values between 5.255 mmol/l and 6.055 mmol/l which increased to 6.350 mmol/l and 6.790 mmol/l. The values for the ad libitum milk replacer group and the cow-calf-I group increased from 7.160 mmol/l and 7.430 mmol/l to 8.010 mmol/l and 8.255 mmol/l. The highest values were found in the treatments cow-calf-II and ad libitum whole milk with 8.780 mmol/l and 7.850 mmol/l. These values increased to 9.160 mmol/l and 8.585 mmol/l (Table 3).

There was no cross-sucking within the cow-calf-groups. In the ad libitum groups one to two calves showed this behaviour. The same was observed in the treatments milk replacer, post feeding area and post feeding area with glucose. In the treatment fixation three calves showed cross-sucking, but this could have been easily eliminated because the cross sucking was possible only due to an insufficient design of the door. Most calves (5 to 8 per observation day) with cross-sucking behaviour belong to the treatment feeding stall without door (Table 4).

Table. 4:
Cross-sucking behaviour

item	number of calves with cross-sucking [n]		
	observation day 1	observation day 2	observation day 3
1	5	5	8
2	0	0	0
3	1	1	1
4	2	2	2
5	7	6	5
6	2	4	5
7	0	0	0
8	1	0	0
9	5	9	8
10	2	1	1
11	2	2	2
12	2	4	3

4 Discussion

The discussion is limited to the parameter cross-sucking and blood glucose level.

In an experiment by Meier (1997) an addition of 2 g of glucose per litre milk replacer showed a reduction of the number of cross-sucking bouts of 0.14 and a duration of 0.27 min per bout in contrast to the control group with cross-sucking bouts of 2.97 and a duration of 3.29 min per bout.

Egle (2004) added an addition of 2 g of glucose per litre milk or milk replacer reduced cross-sucking. The number of cross-sucking bouts was 0.93 and the duration was 2.72 min per bout in contrast to the control group with

cross-sucking bouts of 2.92 and duration of 9.49 min per bout. Even an addition of 1 g of glucose per litre milk or a Glucose-Lick-Stone reduced cross-sucking bouts with a number of 1.5 to 4 and a duration of 2 to 5 min in contrast to a number of 6 bouts per day with a duration of 15 min.

In contrast to that an experiment by Brummer (2004) showed no influence of a Glucose-Lick-Stone on cross-sucking. The mean duration per group and day (11 calves per group) was nearly the same in the control group (42:54 min) and in the experimental group (43:01 min).

In an experiment by Floemer (2006) the cross-sucking behaviour of calves that were fed with whole milk tended to be less than in the group fed with milk replacer. But the blood glucose level increased more sharply during the 15 min after milk intake than in the whole milk group. Generally the blood sampling of the cow-calf group had significantly higher blood glucose levels. In a further experiment the addition of 2 g glucose per litre milk replacer resulted in more cross-sucking than without glucose.

The experiments showed different results as to cross-sucking behaviour.

Our results indicated that there is an influence of the feeding strategy in relation to the blood glucose level. But a higher blood glucose level alone (e. g. open feeding stall) mustn't result in less cross-sucking behaviour.

5 Conclusion

The study indicates three possibilities for reducing cross-sucking behaviour in group housed calves. The practical use of the solutions depends on farm size and the calf-management. In farms, where the teat feeder is running at partial capacity, the solution of fixing the calf after a meal is practical. The feeding stall is closed for about five minutes after the end of the milk meal. In farms with the teat feeder running at full capacity, the solution with the post feeding area seems to be more practical. Due to the fast exit of the calves from the feeding stall, probably more calves can drink per station. The solution with foster cows is qualified for fewer farms. Generally calves are being favoured that take concentrates and less milk very early cause of economic reasons. However there is a potential in the foster cow-rearing method especially for organic dairy farmers, because calves show no cross-sucking and there might be health-benefits in foster-cow reared calves.

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