Factors Affecting IgG Absorption By Jersey Calves

E. H. Jaster
California Polytechnic State University
San Luis Obispo

Summary

Serum immunoglobulin levels of Jersey calves fed colostrum of high or low IgG_1 concentrations in one of two quantities and at one or two times during the first 12 hours after birth were evaluated in this study.

The study involved 24 Jersey calves randomly assigned to one of four treatment groups (6 calves per group).

Groups 1 and 2 were fed colostrum high in IgG_1 (84 mg/mL). Groups 3 and 4 were fed colostrum low in IgG_1 (31.2 mg/mL). Two of the groups (1–high IgG_1 and 3–low IgG_1) were fed 4 liters at birth (0 hours). The other groups were fed 2 liters at birth and 2 liters at 12 hours.

The results support *feeding Jersey calves two (2) separate feedings of high quality colostrum to maximize the colostral IgG_1 intake.* Calves fed 2 liters (L) of high quality colostrum at birth and 12 hours later had greater concentrations of IgG_1 24 hours after birth. They also had higher apparent efficiency of absorption at 48 hours than calves fed similar IgG_1 concentrations one time only at birth.

New research evaluating quality, quantity and timing of colostrum feeding suggests that Jersey calves will gain greater passive immunity when they receive two separate feedings of high quality colostrum as measured by IgG_1. The study, published in the January, 2005 *Journal of Dairy Science*, was supported by a grant from the AJCC Research Foundation.

Purpose and Background

Much research has been directed toward colostrum feeding programs with large breed dairy cattle, but information is limited on serum immunoglobulin G_1 concentrations when colostrum with high and low concentrations of Ig is fed during the first 12 hours after birth in Jersey calves. Also, limited information is available, especially for Jersey calves, about the interaction of colostrum quality, the quantity fed, and the timing of colostrum feeding. Results of this experiment will help to provide recommendations on feeding colostrum to Jersey calves in order to reduce morbidity and mortality and increase performance.

Inadequate or improper colostrum feeding and management cause a significant portion of the calf morbidity and mortality on United States dairy farms. Providing adequate colostrum of suitable quality is critical during the first 24 hours of life.

Colostrum is the secretion from the mammary gland for the first 24 hours after calving. Total solids composition of colostrum is 21% to 27%, compared to 12% to 13% in whole milk. Colostrum contains high levels of immunoglobulins, which play an important role in establishing passive immunity in the young calf, and also play an important role at the localized intestinal level. Immunoglobulin (Ig) intake will depend on colostrum intake and its Ig concentration. Amount of Ig in colostrum varies according to the dam's disease history, volume of colostrum produced, season of year, time after calving, and also breed. The average concentration in colostrum of Holstein cows has been reported as 48.2 g/L, and from Jersey cows as 65.8 g/L.

There are three types of Ig in colostrum, IgG, IgM and IgA, which typically account for about 85% to 90%, 5%, and 7%, respectively, of total Ig in colostrum. There are two isotypes of IgG: IgG_1 and IgG_2. These Ig work together to provide the calf with passive immunity (immunity provided by the cow and not synthesized by the calf) until the calf's own active immunity develops.

The Ig ingested by the calf is taken up by the epithelial cells of the small intestine and passes into the lymph spaces and then into the blood circulation through the thoracic duct. This transfer mechanism (passive transfer) starts to decline at approximately 12 to 23 hours after birth and ceases on average at 24 hours.

While the level of Ig that provides adequate protection will vary with factors such as exposure to infectious organisms, stress, environment, and ambient temperature, a management target of 10 mg/mL has been suggested as a minimum level of IgG in the serum of calves by approximately 24 hours of age to prevent failure of passive transfer.

Discouragingly, over 40% of dairy heifer calves sampled by the National Dairy Heifer Evaluation Project had serum IgG concentrations below 10 mg/mL, and more than 25% of calves were below 6.2 mg/mL, which put calves at a much greater risk.

Study Procedure

Table 1 summarizes the quality and quantity of colostrum administered and timing of subsequent colostrum feedings in this experiment. Fresh colostrum from first milkings (high IgG_1 colostrum) and colostrum from second and third milkings (low IgG_1 colostrum) was collected from multiparous donor Jersey cows as they calved, then pooled and frozen in 2 liter (L) bottles.

The time of first colostrum feeding was designed as 0 hour (groups 1, 2, 3 and 4); subsequent feedings (group 2 and 4) were made 12 hours (h) later. Calves were fed via nipple bottle, and any colostrum not consumed was administered with an esophageal feeder. Body weights were not different among treatment groups. Calves in groups 1 and 3 were fed whole milk at 10% of body weight at 12 h, with all groups

fed whole milk for the remainder of the study.

Table 1. Design of experiment to study the effects of quality and timing of colostrum ingestion on IgG_1 absorption in Jersey calves.

Treatment Group	Calves (no.)	IgG_1 concentration in colostrum	Volume of colostrum (L) 0 h	12 h	Total IgG_1 ingested in 12 h
1	6	84.0 mg/mL	4	–	336.0 g
2	6	84.0	2	2	336.0
3	6	31.2	4	–	124.8
4	6	31.2	2	2	124.8

Results

Serum protein concentrations. Total serum protein has been used as an estimate of circulating serum IgG concentration and as an indicator of susceptibility to neonatal disease.

Levels before colostrum feeding were relatively low across all groups (Table 2).

Calves in groups 1 and 2, which were fed high quality colostrum (84 mg/mL), had higher concentrations of serum protein at 12, 24, and 48 h than calves fed lower quality colostrum (31.2 mg/mL). At 48 h of age, calves fed 4 L of high quality colostrum (group 1) had approximately 44% greater serum protein concentration than calves fed 4 L of low quality colostrum (group 3).

For calves fed high quality colostrum (groups 1 and 2), no differences in time of colostrum feeding and concentrations of serum protein were detected at 12, 24, and 48 h. Similarly, no differences were detected in time of colostrum feeding and concentrations of serum protein at 12, 24, and 48 h for calves fed low quality colostrum (groups 3 and 4).

Mean serum protein for groups 3 and 4 at 12, 24 and 48 hwas <5.0 g/L, which has been reported as an indication of failure of passive transfer of immunity.

Serum IgG_1 concentrations. Levels at 12, 24 and 48 h after birth are reported in Table 3. A negligible amount of serum IgG_1 was detected in calves at birth before colostrum feeding; there was no difference between groups.

Calves fed 4 L of low quality colostrum at birth (group 3) had higher levels of IgG_1 at 12 and 24 h than calves fed 2 L of low quality colostrum at birth and 2 L at 12 h (group 4). Differences were not present at 48 h. The lack of effect of feeding low quality colostrum at rates of 4 L at 0 h compared to 2 L at 0 h and 2 L at 12 h suggests that offering calves a second feeding of low quality colostrum will not provide adequate Ig protection.

It is generally accepted that failure of passive transfer is indicated when a blood Ig concentration is less than 10 mg/mL at 48 h of age. A concentration of 15 mg/mL probably is more desirable as a management target to reduce calf morbidity and morality. As reported in Table 3, calves fed low quality colostrum (group 4) did not achieve the management target of 15 mg/mL. In contrast, calves fed colostrum relatively high in IgG_1 content (groups 1 and 2) had higher serum IgG_1 concentrations as 12, 24 and 48 h than calves receiving low quality IgG_1 colostrum.

Table 2. Serum protein concentrations in Jersey calves.

Treatment Group	Time after first colostrum 0 h	12 h	24 h	48 h
	(g /100 ml)			
1	3.83	6.08	6.85	6.58
2	4.20	6.10	7.20	6.86
3	3.32	4.65	4.35	4.58
4	3.66	4.00	4.13	4.30

Table 3. Serum IgG_1 concentrations in Jersey calves.

Treatment Group	Time after first colostrum 12 h	24 h	48 h
	(mg / mL)		
1	32.66	39.66	38.66
2	34.33	45.83	45.66
3	16.12	15.83	13.81
4	7.75	10.91	9.95

Comparing the groups fed high IgG_1 colostrum, calves fed 4 L at birth (group 1) had similar serum IgG_1 concentrations at 12 h as those calves fed 2 L (group 2). However, serum IgG_1 concentrations of calves in group 2 were 18% greater at 24 and 48 h than concentrations measured in group 1 calves (4 L high IgG_1 colostrum at 0 h). Previous studies have found a similar pattern of absorption for IgG_1 and reported a negative correlation between the efficiency of absorption and the mass of immunoglobulin G_1 fed. It has been suggested that there is a physiologic limitation to the mass of immunoglobulin that can be absorbed from a given volume of colostrum.

Apparent efficiency of absorption (AEA) of serum IgG_1 was measured at 48 h to assess the success of the passive transfer of immunity. Calves receiving 2 L at birth and 2 L at 12 h of high IgG_1 colostrum (group 2) had higher mean apparent efficiency of IgG_1 absorption than group 1 calves fed 4 L of colostrum high in IgG_1 at birth. Similar AEA rates were noted for group 1 and 3 calves. However, group 4 calves fed 2 L of low quality colostrum at 0 and 2 L at 24 h had a lower AEA compared to group 1, 2 and 3 calves.

Discussion

The results from this study show the importance of colostral quality on IgG_1 intake and absorption. Jersey calves that received high quality colostrum (84.0 mg/mL IgG_1) had higher concentrations of IgG_1 and total serum protein than calves that received low quality colostrum (31.2 mg/mL IgG_1).

It is critically important to feed high quality colostrum immediately after birth. The intestine of the newborn is capable of absorbing large protein molecules (such as Ig) intact within the first 24 hours of life, resulting in an increase in circulating IgG concentrations in the calf's blood. Providing calves with high quality colostrum soon after birth maximizes absorption potential of Ig. With increasing age, there is a progressive decrease in absorption rate as colostrum feeding is delayed.

The study also supports feeding Jersey calves two (2) separate feedings of high quality colostrum to maximize the colostral IgG_1 intake. Calves fed 2 L of high quality colostrum at 0 and 12 h had greater concentrations of IgG_1 after 24 h and higher apparent efficiency of absorption at 48 h than calves fed similar IgG_1 concentrations one time at 0 hours.

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