Determination of the Minimum Individual Cow Colostral Immunoglobulin G (IgG) Concentration Required for Pooling to Achieve Adequate Passive Immunity (API) in Dairy Calves

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Introduction

Calves depend on ingestion of colostrum after birth for absorption of at least 150-200g of IgG to achieve adequate passive immunity (API).[1] Factors affecting the achievement of passive immunity include colostral IgG concentration, calf age at time of colostrum feeding, volume fed, and pooling of colostrum. Negative outcomes associated with failure of transfer of passive immunity (FPI) in dairy calves include increased morbidity and mortality, with 20% of calves in the US suffering from FPI.[2]

Pooling is achieved by mixing colostrum from multiple cows prior to feeding calves. While pooling colostrum minimizes colostrum shortages on dairy farms, it might decrease the IgG concentration fed to the calf due the *dilution effect* because cows producing low IgG colostrum are more likely to produce larger colostrum volumes. Calves that are fed pooled colostrum have been shown to be twice as likely to have FPI compared to calves fed colostrum from an individual cow.[2]

Pooling colostrum is inevitable on dairies, therefore recommendations to achieve API in calves following pooling are warranted. To date, no peer reviewed studies are available describing the minimum individual cow colostral IgG concentration required for pooling.

This study determined the minimum IgG concentration and established an industry standard for dairies that pool colostrum. It also quantified the dilution effect, evaluated other variables that contribute to API, and compared API status to health outcomes in calves fed different pools of colostrum.

Hypothesis

A minimum individual cow colostral IgG concentration is required for pooling to achieve adequate passive immunity (API) in calves fed pooled colostrum.

Specific Aims

1. Determine a combination of factors including parity, individual cow colostral IgG, number of cows contributing to a pool, and first milking colostrum volume that contributes 150–200g IgG in pooled colostrum to achieve API in calves.
2. Quantify the minimum individual cow colostral IgG concentration required for pooling colostrum to achieve API in calves, thereby setting the industry standard.
3. Compare the accuracy of calculating mean pool IgG concentration based on individual cow colostral IgG concentrations with the true pool IgG concentration to evaluate the magnitude of the dilution effect.
4. Compare preweaning API status to average daily gain (ADG), morbidity, and mortality among calves fed different colostrum pools.

Methods

- A randomized cohort study was conducted on a 3,000-cow Jersey conventional dairy in Merced County, CA.
- A sample size of 27 pools with 4-10 cows contributing to each pool was collected, heat-treated, and fed to a total of ~160 calves.
- Colostrum was collected from each cow at first milking and from the pre- and post- heat treatment pools.
  - Cow ID, parity, total number of cows in pool, individual volume contributions, and total pool volume were recorded.
  - IgG concentrations were measured by Brix refractometer and radial immunodiffusion (RID) for individual and pool samples.
- Each calf was fed 4L of colostrum.
  - Colostrum pool fed was recorded.
  - Serum samples were taken after 72 hours and measured for IgG concentrations by refractometer and RID.
  - API status was determined based on serum (>2000 mg/dL).
  - Morbidity, mortality & ADG will be analyzed for correlation to API status when calves are weaned (Aim 4).

Image 1 Colostrum collection

Results

Aim 1. Determining contributing factors to API

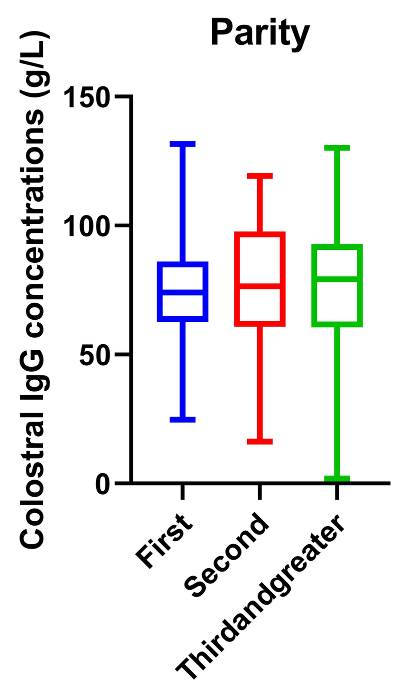

Fig. 1 Parity does not significantly affect colostral IgG concentration.

Descriptive Statistics

Total cows enrolled	201
Median (95% CI) individual cow colostral volume (L)	6.8 (6.1, 7.6)
Median (95% CI) number of cows in a pool	8 (8)
Median (95% CI) total pool volume (L)	55.6 (51.6, 57.2)
Median (95% CI) pool colostral IgG before heat treatment (g/L)	**81.5 (73.0, 91.2)**
Median (95% CI) pool colostral IgG after heat treatment (g/L)	**69.7 (62.3, 78.4)**

Fig. 2 IgG concentrations of colostrum before pasteurization were significantly higher than after pasteurization.

Aim 2. Setting an industry standard for pooling

- Of the factors studied, the number of cows in the pool was the only factor that affected (negatively) the IgG concentration of the post pasteurized colostrum.

Predictive Linear Regression Model

Number of cows in pool	Predicted IgG conc.	95%CI	IgG in 4L	IgG in 4L at low CI
4	80.13	73.1, 87.1	320.52	292.4
5	76.19	69.2, 83.2	304.76	276.8
6	72.25	65.2, 79.3	289	260.8
7	68.31	61.3, 75.3	273.24	245.2
8	64.37	57.4, 71.4	257.48	229.6
✓ 9	✓ 60.43	53.4, 67.4	241.72	213.6
10	56.49	49.5, 63.5	225.96	✗ 198

Fig. 3 Pools should remain smaller than 10 cows to avoid FPI in calves, with an increase in the standard of colostral IgG from 50 g/L to 60 g/L.

Aim 3. Magnitude of the dilution effect

Calculated pool IgG concentration

Median (95% CI) individual colostral IgG (g/L)
74.4 (70.9, 79.6)

vs.

True pool IgG concentrations

Median (95% CI) pool colostral IgG before heat treatment (g/L)	
81.5 (73.0, 91.2)	Significant ✓

Median (95% CI) pool colostral IgG after heat treatment (g/L)	
69.7 (62.3, 78.4)	Not significant ✗

Fig. 4 Though the pre-pasteurization IgG concentration differs significantly from the calculated mean, it is not fed to calves and is therefore not practically meaningful.

Discussion

- The number of cows in the pool negatively affects IgG concentration. Pooling colostrum should be done with 9 cows or fewer.
- The dilution effect may contribute to this but has not been proven to do so in this study.
- The industry standard for pools should be increased from 50 g/L to 60 g/L for colostral IgG when pooling.

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References

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