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THE COLOSTRUM COUNSEL

The Critical Role of Passive Immunity in Calf Health and Development

Introduction

Newborn calves have an underdeveloped immune system and no circulating maternal antibodies, leaving them highly susceptible to infectious diseases. Unlike humans, where passive immunity is transferred through the placenta, the synepitheliochorial placenta of cattle prevents the transfer of immunoglobulins from the dam to the fetus (Peter, 2013). As a result, calves are born without humoral immunity and rely entirely on colostrum intake for passive immunity.

Immunoglobulins and their role in calf immunity

At birth, calves are assumed to absorb immunoglobulins from colostrum through pinocytosis (Stott et al., 1979) (Figure 1). However, intestinal permeability declines rapidly, with a significant reduction in immunoglobulin absorption after 12 hours (Stott et al., 1979b; Bush and Staley, 1980).

The exact mechanism behind this decline is unclear, but it is thought to result from the depletion of pinocytotic activity or the replacement of enterocytes with mature epithelial cells (Broughton and Lecce, 1970; Smeaton and Simpson-Morgan, 1985; Weaver et al., 2000).

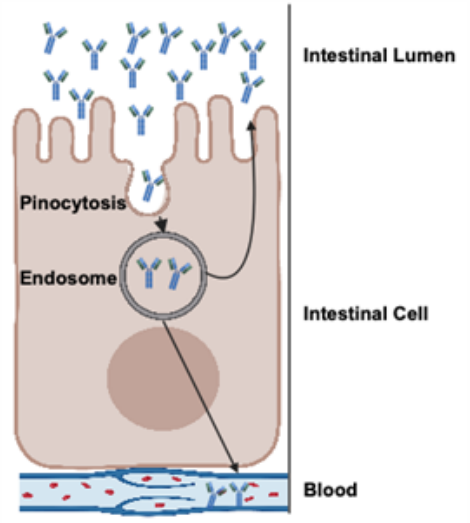

Figure 1. Process of immunoglobulin absorption through pinocytosis in the intestinal cell.

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What immunoglobulin?

Although colostrum contains other immunoglobulins, such as IgM and IgA, IgG is the predominant antibody (Figure 2) and the primary focus of research due to its central role in passive immunity. Once absorbed, IgG neutralizes pathogens, enhances opsonization, and supports adaptive immune development (Janeway et al., 2001). Additionally, IgG can be re-secreted into the intestine, contributing to mucosal immunity alongside IgA (Besser et al., 1988; Ulfman et al., 2018) (as shown in Figure 1).

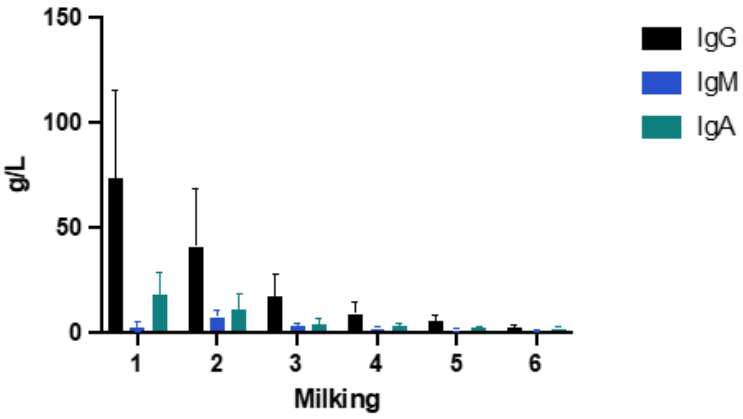

Figure 1. Postparturient colostral IgG, IgA, and IgM concentrations for 6 milkings after calving at 12 hours intervals. Data from Stott et al. (1981).

Effects of passive immunity

Short-term effects

Failure of transfer of passive immunity (FTPI) is typically defined as serum IgG < 10 g/L in a calf at 24 to 36 hours of age (Weaver et al., 2000). Using this threshold, Raboisson et al. (2016) conducted a meta-analysis of 10 studies and found that dairy calves with FTPI had:

- 2.12 times higher risk of mortality
- 1.75 times higher risk of respiratory disease
- 1.51 times higher risk of diarrhea
- 1.91 times higher risk of overall morbidity
- 81 g/day lower average daily gain

Cumulatively, based on the study results, the estimated economic impact of FTPI was found to be $89.27 CAD per case.

Similarly, Abdallah et al. (2022) conducted a meta-analysis on non-replacement dairy calves (veal or dairy-beef) using the same FTPI threshold (< 10 g IgG/L) and found that affected calves had:

- 2.46 times higher odds of mortality
- 3.03 times higher odds of diarrhea

More recent research suggests that higher thresholds should be used to define adequate passive immunity. Lombard et al. (2020), through expert consensus, concluded that the traditional 10 g/L cutoff is too low and that achieving higher serum IgG levels is critical for optimal calf health. The recommended thresholds for serum IgG concentrations, total protein, and Brix % are outlined in Table 1.

Category	Serum IgG (g/L)	Total Protein (g/dL)	% Brix	Target (% calves)
Excellent	≥ 25.0	≥ 6.2	≥ 9.4	> 40
Good	18.0 to 24.9	5.8 to 6.1	8.9 to 9.3	~ 30
Fair	10.0 to 17.9	5.1 to 5.7	8.1 to 8.8	~ 20
Poor	< 10.0	< 5.1	< 8.1	< 10

Table 1. Consensus serum IgG concentrations, total protein, and Brix %, along with the suggested targets by Lombard et al. (2020).

Multiple studies have confirmed the benefits of achieving higher passive immunity thresholds. Sutter et al. (2023) analyzed serum total protein data from 3,434 dairy calves sampled between 2 to 7 days of age on a commercial dairy farm. They found that calves with excellent passive immunity (vs. poor) had:

- 50% lower hazard for respiratory disease
- 50% lower hazard for overall morbidity
- 60% lower hazard for mortality
- 0.04 kg/day higher average daily gain

Crannell and Abuelo (2023), also had similar findings. Analyzing serum total protein records from 4,336 dairy calves sampled between 2 to 7 days of age on a commercial dairy farm, they reported that calves with excellent passive immunity (vs. poor) had:

- 33% lower hazard for diarrhea
- 28% lower hazard for respiratory disease
- 34% lower hazard for overall morbidity
- 77% lower hazard for mortality

Long-term effects

Few studies have examined the long-term impacts of passive immunity. DeNise et al. (1989) analyzed serum IgG levels in 1,000 calves sampled between 24 to 48 hours of age and found that for every 1 g/L increase in IgG, first-lactation milk yield increased by 8.5 kg. Additionally, calves with IgG < 12 g/L had the highest rates of culling for low production in their first lactation and increased mortality from birth to 180 days.

More recently, Crannell and Abuelo (2023) applied the Lombard et al. (2020) passive immunity thresholds and found that calves in the excellent category (vs. poor) had:

- 2.78 times higher hazard of being inseminated
- 2.22 times higher hazard of becoming pregnant as a heifer
- 1.32 times higher hazard of calving for the first time

Similarly, Faber et al. (2005), although not directly measuring IgG, reported that calves fed 4 L of colostrum at birth produced 955 kg more milk in their first lactation and 1,652 kg more in their second lactation compared to those receiving 2 L of colostrum.

Going beyond passive immunity

Although IgG and passive immunity have been the primary focus, colostrum contains a variety of bioactive compounds that influence immune system development and gut health (Blum and Hammon, 2000; Fischer-Tlustos et al., 2021). Feeding colostrum soon after birth supports early microbial colonization, promoting beneficial bacteria while reducing potential pathogens (Malmuthuge et al., 2015). Additionally, Fischer-Tlustos et al. (2020) reported that earlier colostrum intake improved villi height and crypt depth, increasing the surface area for nutrient absorption. While IgG is often emphasized, its benefits may be closely linked to other bioactive components that contribute to overall calf health.

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Take away messages

Colostrum is essential for calf immunity, as newborns are born without maternal antibodies and rely entirely on passive transfer for protection. Because IgG absorption declines rapidly, with significantly reduced permeability after 12 hours, timely colostrum feeding is critical. Higher passive immunity improves short-term health by reducing the risk of mortality, respiratory disease, and diarrhea while also enhancing growth. Long-term benefits include improved first-lactation milk yield, lower culling rates, and better reproductive performance. Recent research suggests that the traditional 10 g/L IgG threshold is too low, and achieving higher passive immunity levels is necessary for optimal health and productivity. Ensuring calves receive a sufficient quantity of high-quality colostrum immediately after birth is essential for their health, growth, and long-term success.

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