CHANGES IN SERUM IMMUNOGLOBULINS CONCENTRATION OF NEWBORN CALVES

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Abstract

The changes in the serum immunoglobulins concentration were investigated in newborn heifers from birth to 7 days of age. The mothers of calves were determined serum and colostrum immunoglobulins (Ig) concentration. The research was carried out at the Latvia University of Agriculture (LLU), in dairy farm 'Līgotnes'of the Research and Study Farm 'Vecauce', in a loose housing system with 530 cows, of which 430 were milking cows. The cows during the dry period were kept tethered in the farm. Eighteen heifers and their dams (Latvian Brown and Holstein breeds) which calved from 30 November 2010 to 23 January 2011 were used in this study. The calves' serum total immunoglobulin concentration at birth was 9.0 ± 1.31 mg dL^{-1} (or 0.09 mg $mL^{-1,}$), and after 24 hours (h) it increased significantly to 4.3 mg dL^{-1} (or 0.043 mg mL^{-1}), $p<0.05$. The immunoglobulin G (IgG) concentration in calf serum after birth was 6.8 ±1.50 mg dL^{-1} (or 0.068 mg mL^{-1}), and after 1 day and after 7 days it did not change significantly. The average Ig serum concentration in cows was 12.6 ± 1.36 mg dL^{-1} (or 0.126 mg mL^{-1}), and Ig concentration in colostrum was 18.5 ± 1.68 mg mL^{-1}. On average, close correlation (r=0.56) was found between cow blood serum IgM and colostrum IgM. Correlation between cow and calf IgG serum concentration proved to be weak (r=0.49).

Key words: calves, cows, serum, colostrum immunoglobulins.

Introduction

The calves are born without their own immunoglobulins, hence they get them by drinking colostrum (Jezek and Klinkon, 2004). Colostrum is the first natural food for the newborn calf. It is secreted during the first few days after calving. The importance of colostrum for the health of calves has been known for a long time (Pakkanen and Aalto, 1997). The high level of immunoglobulins is only in the first milking colostrum (Quigley and Martin, 1994; Jezek and Klinkon, 2004). Bovine colostrum is a very rich source of immunoglobulins and their absorption is essential to provide passive immunity after birth. These antibodies protect newborn calves against infectious enteric and respiratory diseases, which are principal reasons for mortality of calves (Pakkanen and Aalto, 1997). The most important aspect of colostral feeding period is timely provision of an adequate amount of hight quality colostrum. The first feeding has the greatest influence on Ig absorption. The timing of colostral feeding is critically important because the intestine of the newborn is capable of absorbting large molecules for not more than 24 hours after birth. At least 100 g of pure Ig must be ingested at each of the first two feedings of colostrum to achieve a blood concentrations of at least 1.0 mg dL^{-1} (or 0.01 mg mL^{-1}) of IgG to reduce the incidence of disease and death. During the first 3 days calves should be fed high quality colostrum. The recommended volume is 1.5 L^{-1} of colostrum for first feeding. The temperature of the colostrum should be 39 °C to ensure good digestion and acceptance (Brant et al., 2001). Immunoglobulins are proteins which are critical to the identifying and detroying pathogens in the animal. There are three major types of Ig in colostrum of cattle: IgG, IgM, and IgA. There are two isotypes of IgG: $IgG_{1,}$ and IgG_2 (Quigley, 2001) These Ig work together to provide the calf with passive immunity until the calf´s own active immunity develops. Colostrum contains 75 mg mL^{-1} IgG, 5 mg mL^{-1} IgA, and 4.9 mg mL^{-1} IgM (Zītare, 2001). Most of the bovine immunoglobulins are IgG, they are transfered from the blood of the cow into colostrum by a higly specific transport mechanism. This mechanism moves large amounts of IgG from blood into the udder. Serum IgG concentrations of the dam decline precipitously, beginning about 2 and 3 weeks prior to calving. IgM and IgA are synthesized by the plasmacytes in the mammary gland (Quigley, 2001). Maternal immunoglobulins are not transfered across the placenta to the fetus in cattle and calves are born with very low concentrations of serum immunoglobulins (Pakkanen and Aalto, 1997). Optimal supply with colostrum of good quality is important for calf health, but good management is also essential. The aim of the research was to estimate the cows' and newborn calves' blood serum and colostrum Ig concentration.

Materials and Methods

The research was carried out at the Latvia University of Agriculture (LLU), in dairy farm 'Līgotnes' of the Research and Study Farm 'Vecauce', in a loose housing system with 530 cows, of which 430 were milking cows. The cows during the dry period were kept tethered in the farm. Eighteen heifers and their dams (Latvian Brown and Holstein breeds) which calved from 30 November 2010 to 23 January 2011 were used in this study. The calves were housed in individual boxes 2 months after birth. All time they had a straw bed, which was regulary changed. First five days of life they got their dams' colostrum: maximum 4 – 6 L^{-1} twice a day. Calves suckled milk from a nipple pail. From first week of life, calves had free access to the starter and hay. After calving, blood samples from calves and their dams were collected. Blood samples of calves

were collected from the jugular vein into vacutainer tube (5 mL^{-1}) at birth, 24 h, and 7 days after calving. Blood samples of cows were collected from the tail vein shortly after partum. Blood was separated for 15 min by centrifugation, chilled (approximaly at 4 °C), and stored prior to the analysis for immunoglobulins (IgA, IgM, and IgG) by Immunturbidimetric method in the Laboratory 'Egila Gulbja Laboratorija' in Riga. Colostrum samples (500 mL^{-1}) were obtained immediately after calving, and after 12 h. Quality of colostrum was estimated using a colostrometer by company 'DeLaval' (Biogenics – Colostrometer, 1980). Before evaluation, colostrum was heated till 22 °C. The colostrometer evaluates colostrum's quality (or Ig concentration) as superior – 50 to 140 mg mL^{-1}, moderate – 30 – 50 mg mL^{-1}, or inferior < 30 mg mL^{-1}. These quality levels are also coded by colour on the colostrometer as green, yellow, and red (Fleenor, Stott, 1980). Colostrum was devided into two 50 mL^{-1} samples, stored frozen at 20 °C, and shipped to the Laboratory of Food processing of the Faculty of Food Technology of the LLU. Colostrum samples were analysed for immunoglobulins (IgA, IgM, and IgG) by Turbidimetric method. Statistical analysis of the data was perfomed by using Microsoft Excel. Statistical analysis of results was perfomed by using a T-test. Statistical significance ($p<0.05$) was indicated with different alphabet letters in superscript.

Results and Discussion

In this research, Ig concentration in cow blood serum was determined shortly after calving. The results showed that total cow serum Ig concentration was 12.6 ± 1.36 mg dL^{-1} (or 0.126 mg mL^{-1}) at various intervals - 5 – 24 Ig mg dL^{-1} (or 0.05 – 0.24 mg mL^{-1}) (Table 1).

Table 1

Levels of immunoglobulins in cow (n=18) blood serum

Parameters	$\bar{x} \pm s_{\bar{x}}$	Min	Max	Cv%
Lactation	2.6 ± 0.23	1	4	8.8
Total Ig, mg d^{L-1}	12.6 ± 1.36	5	24	45.7
IgM, mg dL^{-1}	6.6 ± 0.97	1	15	62.5
IgG, mg dL^{-1}	6.0 ± 0.82	1	17	57.7

The average age of the cows was 2.6 lactations, and the coeficient of variation was 8.8%, which indicates that the model group is leveled. The chosen model group shows the cows' average age in the farm - 2.4 lactations. IgA was not observed in blood serum. It is mentioned in the literature that immunoglobulin gets into cow udder with blood and synthesides. Compared with blood serum, IgA concentration in colostrum is higher (Neilands, Zītare, 1988). In our research, IgG concentration contained 6.0 ± 0.82 mg dL^{-1} (or 0.06 mg mL^{-1}). The first milking immunoglobulin concentration was 88.1 mg mL^{-1} (Table 2), which was superior quality of colostrum (Fleenor and Stott., 1980), but after 12 h it was decreased significantly (52.1 ± 4.95 mg mL^{-1}). In publications scientists has found that high level of immunoglobulins is only in the first milking colostrum (Quigley and Martin, 1994; Jezek and Klinkon, 2004).

Table 2

Levels of immunoglobulins in cow (n=18) colostrum

Parameters	1st milking		2nd milking (after 12 hours)	
	$\bar{x} \pm s_{\bar{x}}$	Cv%	$\bar{x} \pm s_{\bar{x}}$	Cv%
Ig used by colostrometer, mg mL^{-1}	88.1 ± 5.27 [a]	25.4	52.1 ± 4.95 [b]	40.3
Total Ig, mg mL^{-1}	18.5 ± 1.68	38.4	17.0 ± 1.63	40.7
IgA, mg mL^{-1}	2.6 ± 0.11	18.0	2.6 ± 1.17	28.7
IgM, mg mL^{-1}	2.9 ± 0.12	17.4	2.9 ± 0.11	15.9
IgG, mg mL^{-1}	13.0 ± 1.63	53.6	11.5 ± 1.64	60.5

[a, b] – averages of immunoglobulin level with different superscripts differ significantly ($p<0.05$)

In the present study, cow age did not significantly affect Ig concentration in colostrum ($t_{Stat} = 34.0 > t_{Critical} = 4.2$ where $p=1.75>0.05$), correlation was r=-0.34. This is contrary to the data in the literature, where the colostral immunoglobulin level rises with the number of lactations (Avendano-Reyes and Saucedo-Quintero, 2004; Eihvalde and Kairiša 2010). In our research, concentration of IgA, IgM un IgG remained at the same level for the next 12 h,

which confirms of other researchers findings (Elfstrand et al., 2002). The total Ig concentration in colostrum was 18.5 mg mL^{-1}; wheares various literature sources indikate, that the total amount of colostrum Ig can be 93 – 101 mg mL^{-1}, IgA - 1.6 – 6.2 mg mL^{-1}, IgM - 3.4 – 6.1 mg mL^{-1} and IgG - 54 – 93 mg mL^{-1} (Pakkanen and Aalto, 1997; Elfstrand et al., 2002; Quigley et al., 1995). In our study, total Ig and IgG was several times less than found in the literature.

The research shows how Ig concentration in cow blood serum influences Ig concentration in colostrum (Table 3).

Table 3

Correlation coefficient (r) between cows serum Ig and colostrum Ig concentration in cows (n=18)

Serum	Colostrum			
	Total Ig, mg mL^{-1}	IgA, mg mL^{-1}	IgM, mg mL^{-1}	IgG, mg mL^{-1}
Total Ig, mg dL^{-1}	- 0.08	0.19	0.58*	- 0.13
IgM, mg dL^{-1}	0.00	0.16	0.56*	0.01
IgG, mg dL^{-1}	- 0.22	0.13	0.30	- 0.22

* $p<0.05$

A negative correlation was observed between the cow blood serum Ig and colostrum Ig concentration, which shows that the concentration of cow blood serum Ig did not affect the concentration of Ig in colostrum. Negative correlation was between IgG concentration in the cows blood and colostrum (r=-0.22). It is contradiction to how scientists say. They say that the primary immunoglobulin in bovine colostrum is IgG, which is derived from maternal serum IgG (Weaver et al., 2000). An average close correlation (r=0.56) was found between cow blood serum IgM and colostrum IgM, which demonstrates, that concentration of IgM in colostrum is affected by the concentration of IgM in the cow blood serum.

Health of some days old calves can be evaluated by immunoglobulins concentration in blood serum (Figure 1).

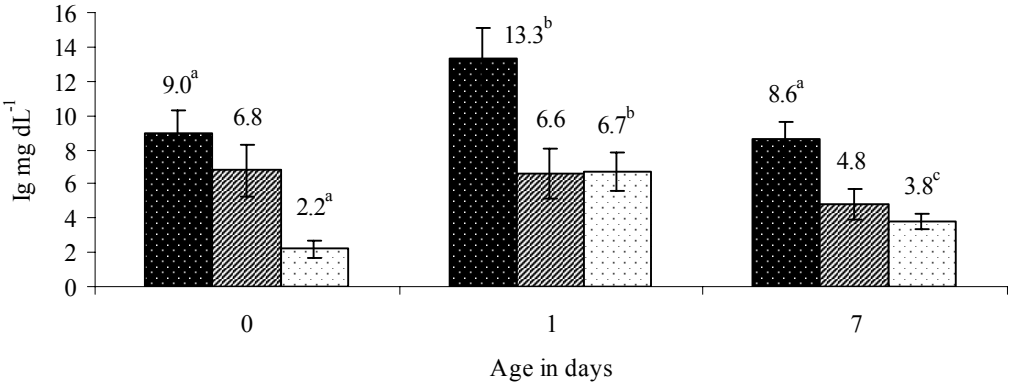

Figure 1. Changes in calf serum Ig after birth (n=18):
[a, b, c] – averages of immunoglobulin level with different superscripts differ significantly ($p<0.05$).
lg (total) lg G lg M

The success of passive immunity transfer is typically assessed by measuring calf blood serum IgG concentrations at 24 to 48 hours after partus. In our research, total Ig concentration in blood of the newborn calf was 9.0 ± 1.31 mg dL^{-1} (or 0.09 mg mL^{-1}), and after 24 hours it increased significantly to 4.3 mg dL^{-1} (or 0.043 mg mL^{-1}), $p<0.05$. It is mentioned in the literature that in the blood serum of newborn calves Ig cannot be found at all or can be found in small amounts - about 5 mg dL^{-1} (or 0.05 mg mL^{-1}) (Trubka, 1999). In our research (24 hours after birth), correlation between Ig concentration in colostrum and in blood serum the correlation was negative, which confirms inferior Ig absobtion in calves blood. IgG concentration in the calf blood serum after birth was 6.8 ± 1.50 mg dL^{-1} (or 0.068 mg mL^{-1}), and after 1 day and 7 days it did not change significantly. In the literature reported, that the blood serum IgG concentration was higher than 10 mg mL^{-1} by 24 hours after birth, it provides successful passive immunity. (Shea et al., 2009). Calves with high serum immunoglobulins have lower mortality rates than calves with serum IgG < 10 mg mL^{-1} (Godden, 2009). Whereas IgM concentration in the blood serum at the

calf birth was 2.2 ± 0.50 mg dL^{-1} (or 0.022 mg mL^{-1}), after 24 hours it increased significantly to 4.5 mg dL^{-1} (or 0.045 mg mL^{-1}) ($p<0.05$), but after 7 days it decreased significantly to 2.9 ± 0.43 mg dL^{-1} (or 0.29 mg mL^{-1}). Ig concentration in calves blood clarifies the risk factor of calves diseases. Blood serum concentration in calves may be influenced by many factors, including calf age at first feeding, sex of the calf, body weight, amount of Ig consumed, colostrum quality, and method of colostrum feeding (Gvozdic et al., 2008). The IgA concentrations in calves serum were not found.

The research shows how Ig concentration in cows' blood serum influences Ig concentration in new-born calf blood serum (Table 4).

Table 4

Correlation coefficient (r) between cows and newborn calves Ig serum concentration shortly after calving

Calf serum	Cow serum		
	Total Ig, mg dL^{-1}	IgM, mg dL^{-1}	IgG, mg dL^{-1}
Total Ig, mg dL^{-1}	0.45	0.20	0.51*
IgM, mg dL^{-1}	- 0.02	0.06	- 0.12
IgG, mg dL^{-1}	0.41	0.15	0.49*

* $p<0.05$

Our research showed that between the cow and the calf IgG concentration in blood serum there was weak correlation (r=0.49), which confirms researches of other scientists, that transplacental transport of proteins is a selective process, singly only IgG, and not IgM or IgA, cross the placental barrier (Klaus et al., 1969).

Conclusions

The average Ig concentration in cows serum was 12.6 ± 1.36 mg dL^{-1} (or 0.126 mg mL^{-1}). In first milking, colostrum Ig concentration was 18.5 ± 1.68 mg mL^{-1}, but in the 2nd milking colostrum was by 1.5 mg mL^{-1} lower. An average close connection (r=0.51) was found between cows blood and colostrum IgM concentration. The newborn calves blood serum at birth contained 9.0 ± 1.31 mg dL^{-1} (or 0.09 mg mL^{-1}) Ig, 24 hours after birth Ig concentration was higher than 4.3 mg dL^{-1} (or 0.043 mg mL^{-1}), there were significant differences ($p<0.05$). A statistically significant correlation was (r=0.49) detected between IgG concentration in cow and in calf serum. Whereas IgA was not found in the cow and calf blood serum. Neonates with not adequate Ig concentration in blood serum can easily suffer from diseases if placed in a filthy environment or exposed to hidly virulent organisms.

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