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PASSIVE IMMUNIZATION OF NEONATAL CALVES WITH POST LACTEAL SECRETION

THE UNIVERSITY OF ARIZONA M.S. 1983

PASSIVE IMMUNIZATION OF NEONATAL CALVES WITH POST LACTEAL SECRETION

by

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ABSTRACT

Immunoglobulins (Ig) in bovine post lacteal secretion were investigated as a source of passive immunity for colostrum deprived neonatal Holstein calves. Mammary secretion collected at 8, 10 or 15 days after cessation of milking was blended into 2 treatment pools based on individual Ig concentration, 1) low pool (<10 mg/ml), and 2) high pool (>14 mg/ml). Mean pool Ig levels were low 6.8 mg/ml, and high 34.3 mg/ml. Twenty newborn unnursed calves were allotted randomly by sex, 10 to each treatment and fed 1 liter of pooled secretion at birth and again at 12 h. Calves fed the high Ig pool secretion had a greater ($P<.05$) mean serum Ig titer, 3.6 mg/ml vs 1.3 mg/ml. Mean calf serum Ig at 0, 24 and 48 h for low and high pool treatments were (mg/ml):.02, 2.00,1.74 and 0.90, 5.53, 4.51, respectively. No health problems occurred to weaning at 4 wk of age.

INTRODUCTION

Bovine neonates depend on ingestion and absorption of immunoglobulins (Ig) from the first milk "colostrum" for passive immunity during the first few weeks of life until active antibody synthesis begins. Maternal plasma proteins including IgG_1, IgG_2, IgM and IgA are selectively transported unchanged across the mammary barrier into the colostrum at levels several times greater than the dams Ig blood titer.

Proportionately, Ig may represent 6 to 9% of the total solids in the colostrum and IgG_1 may account for over 70% of the Ig complex. Following parturition, the level of colostral Ig declines sharply within a few days to less than 0.1% of the normal milk solids content.

Near the end of lactation and after cessation of milking there again is an increased selective transfer of serum Ig into the mammary gland but to a lesser extent than occurs at parturition. There is also an increase in bacteriostatic agents, including lactoferrins, above that normally found in colostrum and normal milk.

The purpose of this experiment was to determine if post lacteal secretion can serve as a source of passive immunity, when fed in place of colostrum, to neonatal dairy calves.

REVIEW OF LITERATURE

Introduction

This review is concerned mostly with immunological and bactericidal changes that occur in the bovine mammary gland and passive immunization of the bovine neonate. References to other species will be included for comparative purposes. More extensive reviews on this subject have recently been published (Logan, 1978; Bush and Staley, 1980; Larson et al., 1980; Roy, 1980; Butler, 1981).

Immunogenicity of Bovine Mammary Secretion

Immunoglobulins in Colostrum

Bovine colostrum, or first milk is a special lacteal secretion produced at parturition. It generally contains 27% or more total solids compared to about 12.5% in whole milk. This difference is primarily found in the protein fraction (18 vs 3.2%) wherein the colostral protein is composed largely of Ig derived selectively from the blood (IgG_1, IgG_2, IgM, IgA) and synthesized (IgM, IgA) in the mammary gland (Pierce and Feinstein, 1965; Butler, 1971, 1974; Mach and Pahud, 1971; Newby and Bourne, 1977; Larson et al., 1980).

Normally bovine milk contains less than 1 mg/ml of Ig. In contrast, colostrum may contain 50 to 150 mg/ml of Ig wherein IgG_1 is the primary fraction. Accordingly, colostral Ig composition is approximately 70 to 80% IgG_1, 10 to 20% IgG_2, 7% IgM and 5% IgA (Butler, 1974; Sasaki, 1976). Other ruminants (goat, sheep, deer, etc.) and related ungulates (pig, horse, camel, etc.) also secrete large quantities of Ig into colostrum (Brambel, 1970; Butler, 1974).

Accumulation of Ig in the mammary gland from local synthesis has been suggested as an important source of colostral Ig (Mach and Pahud, 1971; Lascelles et al., 1972; Butler, 1974; Larson and Jorgensen, 1974; Newby and Bourne, 1977). However, Sasaki et al. (1976) using radioactive labeled IgG_1 and IgG_2 concluded from their work and other studies with the goat (Askonas et al., 1954) and bovine (Larson and Gillespie, 1957) that any mammary synthesis of Ig is minor compared to transfer of IgG from the blood to the colostrum.

There is a rapid decline in milk Ig level within the first 48 h after parturition in all animal species studied (Butler, 1974). In cows, the level of Ig decreases markedly with successive milkings (Smith, 1959; Henderson, 1971). Bush et al. (1971) observed a decrease in mean colostral Ig titers from 6% at parturition to 2.4% in the third milking at 24 h postpartum.

Immunoglobulins in Milk

Although, concentration of Ig in normal bovine milk is less than 1 mg/ml, IgG_1 is still predominant, being about .4 mg/ml compared to .06 mg/ml for IgG_2 (Butler, 1971; Whitney et al., 1976). This difference indicates that the selective blood transport system for Ig continues to function during lactation and that appearance of Ig in whole milk is not simply a passive transudation or leakage across the mammary barrier. Mackenize and Lascelles (1968) found that selective transfer of IgG_1 in ewes also continues at a low level during lactation.

Near the end of lactation and declining milk yield a gradual rise occurs in the level of mammary Ig in the bovine (Larson and Kendall, 1957). This rise in Ig increases sharply in the post lacteal secretion following cessation of regular milking (Carroll, 1961).

Immunoglobulins in Postlacteal Secretion

Carroll (1961) observed a rise in postlacteal Ig and continued production of whey proteins at a constant rate during the drying off phase of the lactation cycle. He concluded that selective resorption may account for some concentration of whey proteins but that selective transudation of globulins from blood to milk was a more probable cause for the steady rise in Ig. Other studies, (Murphy et al., 1964; Carroll et al., 1965) confirmed the selective accumulation of IgG in bovine dry secretion but

found that the IgG_1:IgG_2 ratio was much lower than colostrum.

In contrast, Smith et al. (1971) reported a 3 to 5 fold increase in IgG_1 compared to IgG_2 in the nonlactating mammary gland. They suggested that the above workers may have failed to distinguish IgG_2 from the iron-binding protein lactoferrin which is more closely associated with the latter Ig fraction, resulting in a narrowing of the IgG_1:IgG_2 ratio.

Watson et al. (1972) also reported large increases in the concentration of IgG_1 relative to IgG_2 and other Ig during the first 3 days after milking ceased in the bovine. Concentrations of Ig 7 days postlactation were (mg/ml):IgG_1 10.3, IgG_2 2.0, IgM 4.1 and IgA 3.1. They also observed a selective mammary transition of IgG_1 among ewes when milking was stopped early in lactation but IgG_2 concentration was greater when milking ceased late in lactation.

Bactericidal Agents in Mammary Secretions

In addition to Ig, there are also several bacteriostatic agents including lactoperoxidase and lysozyme lactoferrins associated with mammary whey secretions. While the action of these latter protective factors appears to be primarily bactericidal they may interact with specific antibodies to produce a more effective resistance to disease

organisms (Smith and Schanbacker, 1977; Lascelles and Lee, 1978; Reiter, 1979; Newby et al., 1982).

Smith et al. (1971) reported that lactoferrin represented a major component of bovine dry secretion, approximately 20 mg/ml, and that 2 to 3 g of the iron-binding protein was obtained from many nonlactating quarters. Welty et al. (1976) found that lactoferrin concentration varied greatly among postlacteal cows, ranging form 7.1 to 118.5 mg/ml in dry secretion whey. A mean concentration of 13.5 mg/ml was reported by Gaunt et al. (1980) in the dry secretion of 830 Holstein cows 30 days after cessation of milking.

In comparison to dry secretion, the lactoferrin level is relatively low in other bovine lacteal secretions (Groves, 1965; Reiter and Oram 1967; Masson and Heremans, 1971). Average lactoferrin concentrations of 1 to 5 mg/ml have been reported in colostrum and .1 to .35 mg/ml in normal milk (Sneft and Klobasa, 1973; Harmon et al., 1975; Welty et al., 1976; Gaunt et al., 1980).

The presence of relatively large amounts of lactoferrin in the nonlactating mammary gland suggests that, by virtue of its iron-binding bacteriostatic properties, it may play a prominent role in the protection of the involuted gland (Masson and Heremans, 1971; Smith and Schanbacker, 1977; Newby et al., 1982). Also Newby et al. (1982) have suggested that lactoferrin and other lacteal agents in

colostrum having bactericidal activity, may provide some degree of protection to the neonate.

Passive Immunization Via Colostral Ig

Dairy calves are born agammaglobulinemic. Little or no immunoglobulin is present in the blood serum of the calf at birth (Jameson et al., 1942; San Clemente and Huddleson, 1943; Hansen and Phillips, 1947). Investigators (McAlpine and Rettger, 1925; McDiarmid, 1946) found that cows positive to agglutination and compliment fixation tests for Bacillus abortus, Trichomonas foetus (Kerr and Robertson, 1946), Rinderpest (Brown, 1958) and foot and mouth disease (Graves, 1963) do not transmit agglutins for these maladies to their calf in utero.

Inability of the bovine to transfer Ig to the calf in utero has also been observed to occur in other animals including the goat, sheep,pig and horse. This phenomena has been related to the greater number of placental cell layers, 5 to 6, separating the neonatal blood supply from the fetus in these species versus four or less cell layers in man, monkeys, carnivores and rodents wherein Ig is readily transmitted to the fetal blood (Ratner et al., 1927; Brambell, 1970). However, according to Jeffcott (1972), these specie differences in placental cell layers does not mean the latter act as a physical barrier per se to Ig transfer between the maternal and fetal circulation.

In most animals, the body's developing active immune system does not provide a meaningful source of protection against disease until after the first few weeks of life (Leece et al., 1964; Smith et al., 1964). In the bovine, this occurs at 4 to 8 weeks of age (Brambell, 1970; Devery et al., 1979). Therefore, the calf and other agammaglobulinemic neonates must acquire passive immunity to disease via the ingestion of Ig in the maternal colostrum. The protective colostral Ig are absorbed and appear in the serum within a few hours following consumption (Smith and Little, 1922; Jameson et al., 1942; San Clemente and Huddleson, 1943; Hansen and Phillips, 1947).

Mechanism of Colostral Ig Absorption

The unique physiological mechanism that enables the calf to absorb whole proteins including Ig is called "pinocytosis". In this absorptive process, fluid droplets containing the particles to be absorbed are actively engulfed by the cell versus diffusion through the cell wall (Holter, 1959). As such, the colostral Ig which pass unchanged through the intestinal epithelial cells in vacuoles, are secreted into the mesenteric lymphatic circulation and pass into the peripheral blood (Little and Orcutte, 1922; McDiarmid, 1946; Balfour and Comline, 1962).

An interval of 60 to 120 minutes occurs between introduction of whey into the duodenum and appearance of colostrum protein in the lymph. Subsequently, agglutinins

are found in the blood serum 120 to 140 minutes after they first appear in the lymph (Comline et al., 1951)

It is generally concluded that no marked selectivity occurs in the intestinal absorption of Ig in the calf regardless of their differences in molecular weight (Klaus et al., 1969; Penhale et al., 1970; Sawyer et al., 1977). However, some workers have observed that unequal if not selective intestinal absorption may occur among the Ig classes.

Penhale et al. (1973) reported that cessation in absorption of the Ig classes occurred independently at different times after birth with absorption completed at 27 h for Ig G, 22 h for Ig A and 16 h for Ig M. Logan et al. (1978) concluded that the concentration of Ig G in calf serum was manifested earlier than for Ig M or Ig A.

Rate of Ig M absorption has been reported to be slower than Ig G and Ig A (Stott et al., 1976). However, efficiency of Ig M absorption was found to increase as amount of Ig M consumed decreased but no similar relationship occurred with Ig G or Ig A (Stott and Menefee, 1978).

Ability of the neonate to absorb whole proteins is transitory and diminishes rapidly with age. Cessation of Ig absorption in the calf, kid, lamb and foal is primarily influenced by age and generally occurs at 24 h to 36 h after birth regardless if foodstuffs are ingested or not (Howe,

1921; Deutsch and Smith, 1957; Brambell, 1958; Jeffcott, 1972).

However, some workers have concluded that intestinal permeability to Ig may persist in calves up to 48 h after birth. On the other hand, Gay (1965) reported that this special function may be lost in some calves at 6 to 8 h of age. Delaying initial colostrum feeding 2 to 20 h after birth linearly reduced efficiency of Ig absorption by 50% (Kruse, 1970b).

In contrast to age related absorption in the calf etc., cessation of Ig absorption in swine is largely related to feed intake and normally occurs 24 to 36 h after initial ingestion of foodstuffs at birth. However, Ig absorption has been shown to occur up to 106 h after birth when piglets received only water, but no food had been previously ingested (Payne and Marsh, 1962 a,b; Leece et al., 1964; Clarke and Hardy, 1971).

Colostral Ig Titers and Passive Immunity

The importance of colostral passive immunity to the neonatal calf was recognized early by Smith and Little (1922) who observed that new born calves fed colostrum survived whereas calves fed raw milk in place of colostrum generally died in the first week of life from intestinal infection. Neonatal calves not receiving or absorbing sufficient amounts of colostral Ig are readily susceptible

to bacterial invasion, enteritis and septicemia (Gay, 1965; Fey, 1971; Selman et al., 1971).

High morbidity and mortality in calves have been associated with low concentrations of serum Ig (McEwan et al., 1970b; Boyd, 1974; Logan, 1974; McGuire et al., 1976). Kruse (1970a) reported that the increase in Ig concentration in the serum 24 h post colostrum feeding was primarily dependent on the amount of Ig introduced into the calf. Bush et al. (1971) found that 68% of the blood serum Ig in calves could be accorded to differences in the amount of Ig consumed per unit body weight. Meyer and Steinbach (1965) concluded that calves should receive 2 liters of colostrum no later than 8 h postpartum. Stott et al. (1979) found that calves fed 2 liters of colostrum within 4 h after birth had a greater rate of absorption than calves fed 1 or.5 liter and that 2 liters was sufficient to satiate the intestinal absorptive cells.

In addition to amount of colostrum fed, Meyer and Steinbach (1965) reported that concentration of colostral Ig was equally important since all calves fed less than 80g of Ig in their study died. Other workers agree with this finding and recommend calves receive 2 to 3 liters of colostrum at birth containing 50 to 80 mg per milliliter (Kruse,1970a;McEwan et al.,1970a;Fellah,1982).However, Selman et al. (1970) concluded that consumption of large amounts of colostral Ig does not insure correspondingly high serum Ig levels.

In spite of consuming adequate amounts of colostral Ig at birth, wide variations occur in calf serum Ig titers and some calves remain hypogammaglobulinemic (Gay, 1965; Gay et al.,1965;Klaus et al., 1969; Bush et al., 1971). Several workers have observed levels of 10 to 30% hypogammaglobulinemia among calves fed colostrum (Klaus et al, 1969; McEwan et al., 1970b;Sawyer et al., 1977).

Some workers have suggested that variations in serum Ig titers may be related to differences in colostral intrinsic substances (inorganic phosphate, glucose-6-phosphate, lactate, pyruvate, butyrate etc.) that enhance Ig absorption (Balfour and Comline, 1962; Hardy, 1969; Jeffcott, 1972). However, equally wide variations in colostral serum Ig titers were observed among calves fed a uniform pooled source of colostrum in relation to birth weight. It was concluded that calves have marked inherent differences in intestinal Ig absorption (Kuiper, 1976; Wegner and Schuh, 1978).

MATERIALS AND METHODS

Collection and Preparation of Post Lacteal Secretion

Post lacteal secretion was collected from 29 Holstein cows from the University Dairy Research Center at either 8, 10, or 15 days after cessation of lactation and frozen (-20 C). No secretion was obtained from one cow that dried off at 15 days.

Samples taken from the last milking and from each post lacteal secretion were frozen and later analyzed for Ig content. Subsequently, the dry secretions were thawed and combined into two treatment pools according to Ig concentration: 1)< 10 mg/ml, (low), 2) >14 mg/ml, (high). Each dry secretion pool was subdivided into 20 portions containing 1,005 ml and refrozen.

Management of Calves

Four female and 16 male newborn, unnursed Holstein calves were individually penned and randomly allotted according to sex to the dry cow secretion treatments. Each calf was bottle fed 1000 ml of its respective dry secretion at birth and at 12 h and thereafter whole milk at 12 h intervals.

Blood samples were taken by jugular venipuncture in 10 ml vacutainers^{R} prior to each feeding at 0, 24, and 48 h. Serum was separated by centrifugation, transfered into vials and frozen until analyzed.

Single Radial Immunodiffusion Analysis

Single RID was performed using methods similar to those reported by Fleenor and Stott (1983). Whole colostrum was used in sRID analysis to assure maximum accuracy (Fleenor and Stott, 1981).

Antiserum to bovine gamma globulin used in this assay was produced in rabbits following methods similar to those described by Campbell et al., (1970). The antiserum was characterized by double diffusion (ouchterlony) and immunoelectrophorisis. A gamma globulin standard for immunodiffusion analysis was quantitated by Lowry (1951) protein determination and used to standardize a bovine serum working standard. The working standard was then serially diluted with normal rabbit serum to generate a standard curve.

Statistical Analysis

A four parameter logistic transformation compiled by Kuehl (1978) for competitive ligand assays and modified by Fleenor (1982) for RID was used to fit all standard curves. Data were analyzed in part by a statistical computer package (Nie et al., 1975).

RESULTS AND DISCUSSION

Lacteal Immunoglobulins

Mean weights and Ig concentration for the last milking and post lacteal secretion collected at 8,10,and 15 days after the last milking are in Table 1. Individual values are in appendix table 3,4 and 5.

Milk weight and Ig concentrations for the last regular milking were not different among the 3 groups of cows. Mean milk weight and Ig concentration for the last milking for all cows was 5.68 Kg and 1.78 mg/ml. Low level of Ig have been reported in normal milk by other workers (Butler,1971;Sasaki et al.,1976;Whitney et al.,1978).

No post lacteal secretion could be obtained from one cow in the 15 day group. No other cows were ready to dry off so no replacement was made.

Post lacteal secretion weights at 8,10 and 15 days were not different. Concentration of Ig in lacteal secretion was greater ($p<.05$) at 15 days, 21.85 mg/ml, compared to 8 days,10.84 mg/ml,and 10 days,9.30 mg/ml. Mean lacteal secretion weight and Ig concentration for all cows was 2.12 Kg and 13.54 mg/ml. The wide rang observed in post lacteal secretion,0.34 to 64.61 mg/ml. (appendix tables

3,4,5) agrees with other reports (Smith et al.,1971;Watson et al.,1972).

Blood serum immunoglobulins

The Ig concentrations of the pooled dry cow secretions were 6.87 mg/ml (low)and 34.32 mg/ml(high). The pooled secretions were readily consumed by all treatment calves. Mean and range in serum Ig titers for calves fed the low and high Ig pooled dry cow secretions are in Table 2. Individual serum Ig values are in appendix tables 6 and 7. Indivedual calf birth weights are in appendix table 8.

Calves were generally born agammaglobulinemic with only traces of Ig in their blood. However, 2 calves fed the high Ig pooled secretion had initial serum Ig levels of 1.96 mg/ml and 6.87 mg/ml. Similar findings have been reported by other workers, but the cause of this phenomena has not been identified (Pierce, 1955; Klause et al, 1969; Kuiper, 1976; Hoff, 1982). The calf having the highest zero h Ig titer, also had the highest 24 h and 48 h serum values, Table 2. But, the amount of Ig absorbed was not markedly different when Ig values were adjusted for zero h titers.

Serum Ig increased in all calves from 0 to 24 h. However, two calves in the low Ig secretion group had Ig serum titers of only 0.71/mg/ml and .88/mg/ml at 24 h and slightly lower values at 48 h. In general, serum Ig titers among all calves were relatively low. This reflects not only the low Ig concentrations of the pooled dry secretions

but also the limited amounts fed during the first 24 h. This agrees with others who have observed low serum Ig levels among calves fed limited amounts of colostrum (Kuiper, 1976; Fellah, 1982). Several workers conclude that newborn calves should receive an initial feeding of at least 2 liters of colostrum (McEwan, 1970a; Stott et al., 1979; Fellah, 1982). Amounts of dry secretion fed in this study were limited because of the time element required to obtain additional quantities with few cows going dry.

Individual serum values were generally higher among calves fed the high Ig dry secretion. This concurs with the findings of Fellah (1982) who observed a positive linear relationship in calf serum Ig titers and pooled colostrum Ig concentrations. The importance of an adequate colostral Ig content to insure sufficient Ig absorption is supported by several reseachers (Meyer and Steinbach, 1965; Krause, 1970a; McEwan, 1970a). In contrast others have noted little or no correlations between colostrum and serum Ig concentrations (Klaus et al., 1969; Sawyer et al, 1977; Boyd and Hogg, 1981).

Calves were observed until weaned at about 30 days of age. Although initial serum Ig levels were lower than acceptable for adequate protection from disease (McEwan et al.,1970b;Penhale et al.,1970;Boyd,1972;Ferris and Thomas,1974;Barber,1979)the health of all calves was satisfactory. In spite of unusual cold and wet weather during much of the study only one calf in each group

experienced mild diarrhea. It would appear that the low level of Ig absorbed was sufficient to protect the calves in this experiment.

Kuiper (1976) also observed a minimum of health problems among calves having low serum Ig levels. In addition Snyder (1974) investigating the value of feeding fermented colostrum as a source of passive immunity in calves also found very low serum Ig levels but no health problems. These studies were also conducted at the University Dairy Research Center.

It would appear that the low level of dry secretion Ig absorbed was sufficient to protect the calves in this experiment. However, in addition to increased Ig concentration in dry secretion, there is a rise in bacteriostatic agents, including lysozme lactoferrins and lactoperoxidase, which may also provide initial protection against disease producing organisms (Welty et al., 1976;Smith and Schanbacher, 1977; Newby et al., 1982). Therefore, the apparent passive immunity or protective action derived from dry cow secretion in this study cannot be ascribed to the Ig concentration along.

APPENDIX A

TUBULAR DATA

Table 1. Mean Weights and Ig Concentrations for the Last Milking and Post Lacteal Secretions at 8, 10 and 15 Days.

No. Cows	Last Milking		No. Cows	Post Lacteal Secretion		
	Kg	mg/ml		Days	Kg	mg/ml
10	5.67	1.57	10	8	2.23	10.84
10	5.69	1.30	10	10	2.27	9.30
10	6.30	2.46	9	15	1.83	21.25

Table 2. Mean Serum Ig (mg/ml) at 0, 24 and 48 h in Calves Fed Low or High Ig Dry Cow Secretions[a]

Hour	Mean	Range	S.D
	----------Low Ig----------		
0	0.02 c	0.01 - 0.02	0.03
24	2.00 b	0.71 - 8.81	2.45
48	1.74 c	0.61 - 8.19	2.29
	----------High Ig----------		
0	0.90 c	0.02 - 6.87	2.18
24	5.53 b	3.12 - 15.36	3.62
48	4.51 b	1.60 - 10.82	2.55

[a]Low Ig 6.87 mg/ml.and high Ig 34.32 mg/ml.

[b,c]Means with different superscripts with in treatment are different ($p<.05$).

Table 3. Weight and Ig Concentration of Last Milking and 8 Day Post Lacteal Secretion.

Cow No.	Last Milking		Post Lacteal Secretion	
	kg	mg/ml	kg	mg/ml
1.	9.5	0.446	2.1	5.107
2.	11.3	0.342	3.6	2.663
3.	10.4	1.201	7.9	7.182
4.	2.7	1.121	2.2	3.679
5.	3.4	1.121	0.9	8.280
6.	2.2	1.201	0.4	8.280
7.	1.8	3.679	0.6	24.895
8.	4.7	1.287	0.6	14.236
9.	4.9	2.663	0.9	18.540
10.	5.8	2.663	3.1	15.503

Table 4. Weight and Ig Concentration of Last Milking and 10 Day Post Lacteal Secretion.

Cow No.	Last Milking		Post Lacteal Secretion	
	kg	mg/ml	kg	mg/ml
11.	6.3	1.944	4.1	10.529
12.	7.2	0.982	3.6	7.289
13.	4.8	0.789	1.4	7.239
14.	4.7	1.301	0.9	19.023
15.	6.8	0.788	0.4	6.340
16.	5.8	0.677	1.3	3.722
17.	2.9	1.703	2.4	8.412
18.	5.8	0.982	3.6	3.972
19.	7.9	1.301	3.6	10.529
20.	4.7	2.523	1.4	15.863

Table 5. Weight and Ig Concentration of Last Milking and 15 Day Post Lacteal Secretion.

Cow No.	Last Milking		Post Lacteal Secretion	
	Kg	mg/ml	Kg	mg/ml
21	5.4	0.665	1.3	7.031
22	6.8	0.445	1.3	15.286
23	5.8	0.773	3.1	7.547
24	3.1	3.603	0.4	64.613
25	4.0	7.031	1.8	24.817
26	5.4	1.107	2.4	15.186
27	7.2	2.612	1.1	24.817
28	12.0	0.665	4.0	7.031
29	5.8	1.107	1.1	24.817
30	1.3	6.557	Dry Off	

Table 6. Serum Ig Titers (mg/ml) at 0, 24 and 48 h in Calves Fed Low Ig dry Cow Secretion.

Calf No.	Hours		
	0	24	48
1	0.11	1.45	1.45
2	0.01	0.71	0.61
3	0.01	1.27	0.61
4	0.14	2.16	1.45
5	0.23	1.45	1.18
6	0.01	8.81	8.19
7	0.01	0.89	0.71
8	0.01	1.45	1.03
9	0.01	1.66	1.45
10	0.01	1.38	0.70

Table 7. Serum Ig Titers (mg/ml) at 0, 24 and 48 h in Calves Fed High Ig Dry Cow Secretion.

Calf No.	Hours		
	0	24	48
11	0.02	4.89	4.89
12	0.02	3.54	2.29
13	6.87	15.36	10.82
14	0.05	4.58	3.77
15	0.03	4.89	3.77
16	0.02	3.12	3.54
17	0.02	4.90	4.90
18	1.93	6.87	5.99
19	0.02	3.57	3.57
20	0.02	3.57	1.61

Table 8. Calf Body Weights (Kg).

Low Ig Post Lacteal Secretion		High Ig Post Lacteal Secretion	
Calf No.	Weight	Calf No.	Weight
1	38.1	11	39.9
1	44.4	12	44.4
3	40.3	13	40.3
4	35.3	14	39.9
5	39.4	15	52.1
6	44.4	16	44.4
7	40.3	17	39.4
8	52.1	18	35.3
9	44.4	19	38.1
10	39.0	20	43.0
Mean	41.8		41.7

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