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Contents:

Effect of Colostrum Intake on Serum Hormone Concentrations and Immunoglobulin G Absorption in Neonatal Lambs[1]

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Summary

Colostrum contains nutrients, immunglobulins, hormones, and growth promoting substances, such as insulin-like growth factor–I (IGF-1). An experiment was conducted to study the effects of feeding three amounts of colostrum on immunoglobulin G (IgG), and hormone concentrations during the first 18 hours of life. Fifteen Rambouillet x Merino lambs were assigned to three treatments. Pooled colostrum was fed at 10 mL/kg of body weight (BW), 20 mL/kg BW, or 30 mL/kg BW every 3 hours for 15 hours. Blood samples were obtained from lambs immediately after birth and every 3 hours through hour 18. Concentrations of growth hormone (GH), prolactin (PRL), triiodothyronine (T3) and thyroxine (T4) did not differ ($P > .10$) among treatments. Serum IgG, IGF-1 and insulin (INS) increased linearly ($P < .03$) as colostrum intake increased. A quadratic effect ($P = .06$) was detected for concentrations of GH as colostrum amounts increased. Feeding increasing amounts of colostrum following birth influenced serum IgG, INS, IGF-1 and GH concentrations, thereby, influencing both passive immunity and endocrine status in lambs. Feeding 10 mL/kg produce no health- related mortality at either a week of age or at weaning. Ten mL/kg of BW of colostrum every 3 hours for 15 hours may provide sufficient nutrition, growth-promoting factors and IgG to lambs at high risk.

Key Words: lamb, hormone, immunoglobulins, colostrum

Introduction

Colostrum contains nutrients and immunoglobulins, and growth-promoting products in higher quantities than milk from later in lactation (Koldovsky, 1989; Campana and Baumrucker, 1995). Bovine and ovine colostrum is especially rich in IGF-1, INS, PRL, GH, T4 and T3 (Ronge and Blum, 1988; Grosvenor et al., 1992; Campana and Baumrucker, 1995; Mazzone, 1997). Components of colostrum support development and function of the gastrointestinal (GI) tract, establish passive immunity and influence metabolic and endocrine systems and neonatal nutritional status (Koldovsky, 1989; Simmen et al., 1990; Burrin et al., 1995; Mazzone, 1997; Rauprich et al., 2000).

Colostrum intake by neonatal lambs is often insufficient and can cause hypothermia as the lambs' body energy reserves become depleted (Mellor, 1988). Amount of colostrum consumed has also been shown to greatly affect metabolic and endocrine traits in neonatal calves (Hammon and Blum, 1998, 1999). The actual amount of colostrum that should be fed to newborn lambs to ensure survival by avoiding hypothermia and maintaining adequate serum IgG concentrations is not known. Likewise, whether feeding different amounts of colostrum the first day of life affects endocrine profiles and immunoglobulin absorption and growth performance has not been addressed in lambs. The objective of this study was to determine if feeding three amounts of colostrum influences serum IgG, endocrine traits and growth performance in lambs.

Material and Methods

Animal Selection and Management

Fifteen newborn lambs (Rambouillet x Merino; average BW = 5.5 ± 3 kg; mean ± SE, eight males and six females) were selected from nine multiparous ewes. Six ewes produced twins and three ewes produced single offspring. Dams were monitored 24 hours a day during the lambing period. At parturition, lambs were muzzled with JorVet Muzzles (size 13.34 cm or 15.24 cm, Jorgenson Laboratories, Inc., Loveland, CO) to prevent suckling and remained with their dams in individual pens (1.2 m x 1.5 m) except during treatment and blood sample collection. Lambs were weighed, sexed, and ear-tagged within 30 minutes following birth. Lambs were also weighed at weaning (90 ± 2 days; mean ± SD) and weights were adjusted for day of age, sex, age of dam and type of rearing. The protocol for this experiment was approved by the Animal Care Committee of the University of Nevada according to guidelines provided by the

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Consortium (1988).

Treatments and Blood Collection
At birth, lambs (five lambs/treatment) were randomly allotted to treatment with twin lambs produced by a single dam designated to separate treatments. Lambs were tube-fed either 10 mL/kg (three males/two females), 20 mL/kg (two males/three females), or 30 mL/kg of BW (three males/two females) of pooled colostrum 30 minutes after birth. Feedings continued every 3 hours for a period of 15 hours. The 30 mL/kg of BW of colostrum was selected to fulfill the normal amount required for newborn lambs based on previous literature recommendations (Bobb, 1997). The 20 mL/kg and 10 mL/kg of BW treatments were selected to represent one-third and two-thirds below the normal requirements, respectively. Blood samples (5 mL) were obtained via jugular venipuncture from lambs immediately after birth, and then at hours 1, 2, and 3, and every 3 hours thereafter, through hour 18. Blood collection occurred just before lambs were fed.

Blood samples were stored at 4∞C for 24 hours and centrifuged at 2500 x g at 4∞C for 15 minutes. Serum was separated and stored at -20∞ C for later analysis of IgG and hormone concentrations.

Colostrum Pool Collection
Lambs were fed from a pool of colostrum, which was obtained by collecting colostrum at 0, 6, 12, and 18 hours after parturition from 17 ewes. Ewes used for collection of pooled colostrum were vaccinated approximately 4 weeks before parturition with Covexin 8 (Clostridium chauvoei, C. septicum, C. haemolyticum, C. nouvyi, C. tetani, C. perfringens Type C and D, and Bacterium toxoid, Schering-Plough, Omaha, NE). Colostrum was collected using an Alfa Laval Sheep Milker (Alfa Laval Agri Inc., Kansas City, MO). All Alfa Laval Sheep Milker fittings and parts were sterilized between milkings. Before each milking, ewes' teats were cleaned with a diluted Nolvasan solution (Fort Dodge Laboratories, Inc., Fort Dodge, IA). Ewes were given an injection of 20 international units (IU) of oxytocin (AmTech Group, Inc., St. Joseph, MO) intramuscularly (IM) 1 minute before milking. Colostrum was collected in a sterile container, weighed, and frozen in 1.5 liter plastic bottles. Once enough colostrum had been collected, all bottles were thawed using a water bath (37∞ C) and the colostrum was mixed in a large sterile container. Aliquots of the pooled colostrum were measured into 1.5 liter plastic bottles for individual lambs. Colostrum aliquots were then refrozen and thawed when needed at 37∞ C (water bath) at the time of the recipient lamb's birth and through the 18-hour feeding period.

Colostrum pool samples were collected from eight selected lambs' feed aliquots from feeding times 0, 6, and 12 hours. Because the same colostrum was used in all treatments, stratification by treatment group was not necessary. Colostrum pool samples were stored at -20∞ C for analysis of IgG and hormone concentrations.

Laboratory Analyses of Serum and Colostrum
Lamb serum and colostrum pool samples were analyzed for concentrations of IgG, PRL, INS, IGF-1, T3, and T4. Serum PRL was determined using RIA techniques described by Spoon and Hallford (1989), with the revision that colostrum samples were brought to a 1:20 dilution using a .1 M phosphate buffered saline plus .1% gelatin solution. The interassay and intrassay CV were 15% (n = 5) and 9.0% (n = 5), respectively, for serum and the intraassay CV was 3.0 % (n = 2) for colostrum. Serum and colostrum INS concentrations were determined by RIA techniques discussed by Sanson and Hallford (1984). Colostrum samples for the INS RIA were defatted by diluting 1:2 with .1M phosphate buffered saline plus 1% bovine serum albumin (PBS + 1% BSA), centrifuging for 10 minutes at 1500 rpm at 4∞C, and removing the resultant fat layer from the top of each sample. Defatted samples were further diluted 1:20 with PBS + 1% BSA for RIA analysis. Serum INS inter- and intraassay CV were 14.9% (n = 7) and 11.1% (n = 11), respectively. The INS intraassay CV was 7.6% (n = 2) for colostrum. Serum and colostrum IGF-1 concentrations were determined by RIA techniques developed by Berrie et al. (1995). Serum IGF-1 between assay CV was 13.7% (n = 7) and within assay CV was 7.7% (n = 7). Colostrum IGF–1 within intraassay CV was 15.5% (n = 4). T3 and T4 were analyzed using a commercially available solid phase RIA kit (Coat-A-Count, Diagnostic Products Corporation, Los Angeles, CA). Colostrum samples were diluted with analytical grade water to a dilution of 1:3 for both the T3 and T4 RIA's. Inter- and intraassay CV were 10.5% (n = 5) and 12.5% (n = 5) for serum T3 and 7.7% (n = 5) and 6.8% (n = 5) for serum T4. The intraassay CV for colostrum T3 and T4 were 1.9% (n = 3) and 2.9% (n = 2), respectively. Serum and colostrum IgG concentrations were determined by RIA (Richards et al., 1999). Inter- and intrassay CV were 5.4% (n = 8) and 13.3% (n = 7) for serum IgG. Area under the curve for serum IgG was determined by a microcomputer program that employed the algorithm reported by Lunstra et al. (1989). GH was examined in serum sample only. Serum GH concentrations were determined by RIA techniques developed by Hoefler and Hallford (1987) with an intraassay CV of 17.0% (n = 8).

Statistical Analyses
Lamb body weights at birth, 18 hours after birth and at weaning were analyzed with a one-way analysis of variance (ANOVA) using GLM procedures of SAS (SAS, 1996). Serum and colostrum hormone concentrations were analyzed using a split-plot ANOVA with treatment in the main plot and time of sampling in the subplot. The effect of treatment was tested using animal within treatment as the error term. When a significant treatment by time interaction was noted, further analysis with a one-way ANOVA was performed using the SAS GLM procedures (SAS, 1996). Linear and quadratic contrasts were used when a significant F-test ($P < .10$) was noted for treatment.

Results

Hormones and IgG in Colostrum
No time of sampling effect ($P > .10$) for concentrations of IgG, IGF-I, INS, PRL, T3, or T4 was detected. Mean colostrum concentrations for IgG, IGF-1, and INS were 31.6 ± 1mg/mL, 124.2 ± 6.1 ng/mL, and 125.3 ± ng/mL, respectively. Prolactin, T3, and T4 concentrations for pooled colostrum were 1114.3 ± 62.4 ng/mL, 9.2 ± .6 ng/mL, and 11.2 ± .9 ng/mL, respectively. These results confirm that the pooled colostrum fed to lambs was homogenous in IgG and hormone concentrations.

Hormones in Lamb Serum
No treatment x time of sampling interac-

tions (P > .47) were observed for serum concentrations of GH, IGF-I, PRL, T3, or T4. Concentrations of PRL, T3, and T4 did not differ (P > .20) among treatments (Table 1). In contrast, a quadratic effect (P = .06) was detected for concentrations of GH, whereas, a linear increase (P = .01) was observed for concentrations of IGF-I as colostrum intake increased. No time of sampling effect (P > .33) was detected for either T3 or IGF-1. However, a time of sampling effect (P < .002) across treatments was observed for PRL, T4 and GH (Figure 1). Serum PRL concentrations were greater (P < .05) at hours 0 through 4 than for samples collected following that period. Serum T4 concentrations were greater (P < .05) at hours 0, 1, 2 and 3 versus hours 6 through 18. Serum GH concentrations decreased (P < .05) from hour 0 and were lowest at hours 1 through 6. GH increased (P < .05) at hours 9 and 12, after which a decline (P = .04) was noted at hour 18.

A treatment x time of sampling interaction was detected (P = .08) for serum INS (Figure 2). Serum INS did not differ (P > .75) among treatments at hour 0 or 1. However, at hour 2, a linear increase (linear, P = .05) in serum insulin was observed as colostrum intake increased. Insulin concentrations exhibited a linear increase (P < .01) with increased colostrum intake at hours 6, 9, 12, and 15.

Because no detectable levels of IgG were observed in hour 0 samples, and only a few lambs had detectable values at hour 1, data at these times were not included in the data set. A treatment x time of sampling interaction (P = .002) was detected for serum IgG, therefore, treatment effects were examined within sampling time (Figure 3). Serum IgG concentrations exhibited a linear increase (P < .03) with increased colostrum intake at hours 6, 9, 12, 15, and 18. Area under the serum IgG curve differed (linear, P < .01) with total IgG concentrations of 89.0, 179.2, and 264.5 mg/mL for lambs receiving 10, 20, and 30 mL/kg of BW, respectively. These values reflect the available IgG in the systemic circulation of lambs during the 18-hour period.

Lamb Body Weight

Lamb weights immediately following parturition were 5.5 ± .3 kg for all treatments (P = .99). Eighteen hours after parturition, lamb weights did not differ (P = .56) among treatments and were 5.4, 5.5, and 5.8 ± .2 kg for lambs receiving colostrum at 10, 20, and 30 mL/kg of BW, respectively. No lamb mortalities occurred during the first week following birth. Ninety-day adjusted weaning weights were 33.3 kg (SE=2.1 kg) for each treatment (P = .99). One lamb that received the 10 mL/kg of BW was killed by a predator before reaching 90 days of age.

Table 1. Serum hormone concentration (ng/mL) in lambs fed three amounts of colostrum, including growth hormone (GH), insulin-like growth factor-I (IGF-I), prolactin (PRL), triiodothyronine (T_3), and thyroxine (T_4).

	Colostrum, mL/kg body weight [a]					
Hormone	10	20	30	SE	F test [b]	Contrast [c]
GH	7.6	9.7	5.0	.6	.08	Q = .06
IGF-I	145.7	193.6	227.7	8.0	.04	L = .01
PRL	58.5	100.7	75.8	20.0	.41	
T_3	3.6	4.3	3.5	.1	.19	
T_4	96.3	102.2	99.0	2.6	.85	

[a]Treatment: 10 mL/kg, 20 mL/kg, or 30 mL/kg of body weight of pooled colostrum tub fed every 3 hours from hour 0 through 18, n=5 in each group.
[b]F test P values.
[c]Contrast: quadratic = Q; linear = L.

[a]Treatment: 10 mL/kg, 20 mL/kg, or 30 mL/kg of body weight of pooled colostrum tub fed every 3 hours from hour 0 through 18, n=5 in each group.
[b]F test P values.
[c]Contrast: quadratic = Q; linear = L.

Discussion

Hormones in Lamb Serum

Mazzone (1997) reported similar serum T3 and T4 concentrations to those presented in this study. Thyroid hormones were not influenced by feeding. Similarly, Kühne et al. (2000) reported feeding different amounts of colostrum failed to exert an effect on either T3 or T4 concentrations in calves.

No treatment differences were detected for serum PRL, but a time of sampling response was observed. In general, PRL decreased following birth for the 18-hour period. Rauprich et al. (2000) reported a decrease in PRL for the first 4 hours following the first feeding after birth in calves with an increase 24 hours after feeding. In our study, PRL increased at hour 18 compared with the four previous samplings.

Plasma GH concentrations in newborn calves were reported to be minimally influenced by colostrum feeding (Baumrucker and Blum, 1994; Hammond and Blum, 1997). In contrast, GH concentration was influenced by differing amounts of colostrum in lambs in our study. Plasma GH has been associated with nutrient status with feed restriction increasing GH concentrations in growing cattle (Breier and Sauerwein, 1995). Additionally, Rauprich et al. (2000) reported GH was reduced in newborn calves fed high amounts of nutrients. In our study, GH concentrations were the least for the 30 mL/kg of BW treatment, which would be expected, however, the 20 mL/kg of BW treatment was the greatest, whereas, the 10 mL/kg of BW treatment was intermediate. Sampling time across treatment groups also influenced GH concentrations. Serum GH decreased 1 hour after birth and remained similar through hour 6, after which, GH increased through hour 15. Therefore, GH concentrations are not only influenced by amount of colostrum fed, but by time of sampling in lambs the first 18 hours of life.

Concentrations of serum IGF-1 were similar to those noted by Mazzone (1997). The linear increase of IGF-1 with increased colostrum intake may indicate both increased uptake by the neonatal gut, as well as increased production by the neonatal liver. Campbell and Baumrucker (1989) reported that one source of IGF-1 in the neonate may be from absorption of IGF-1 in the small intestine. Although it is unknown if lambs have the ability to absorb colostral IGF-1, Hammon and Blum (1997) reported that IGF-1 is barely

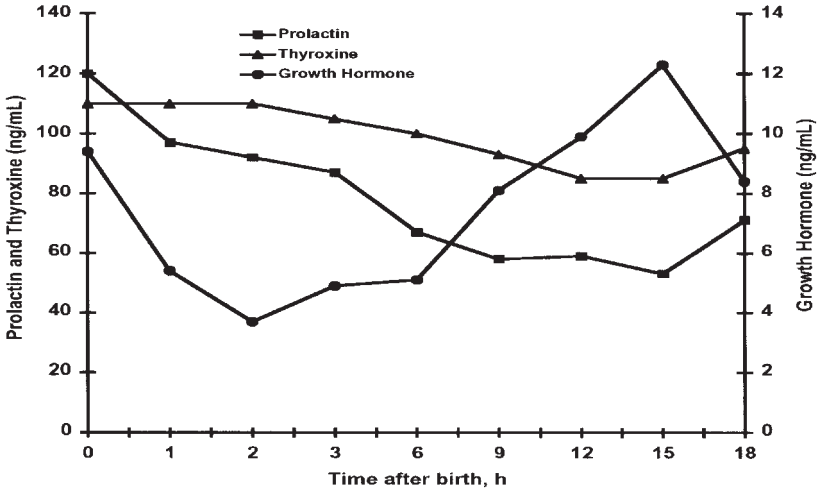

Figure 1. Serum prolactin (PRL), thyroxine (T_4) and growth hormone in lambs across the three treatments from birth through hour 18 (treatment x time of sampling; P > .47; time of sampling effect; P < .002).

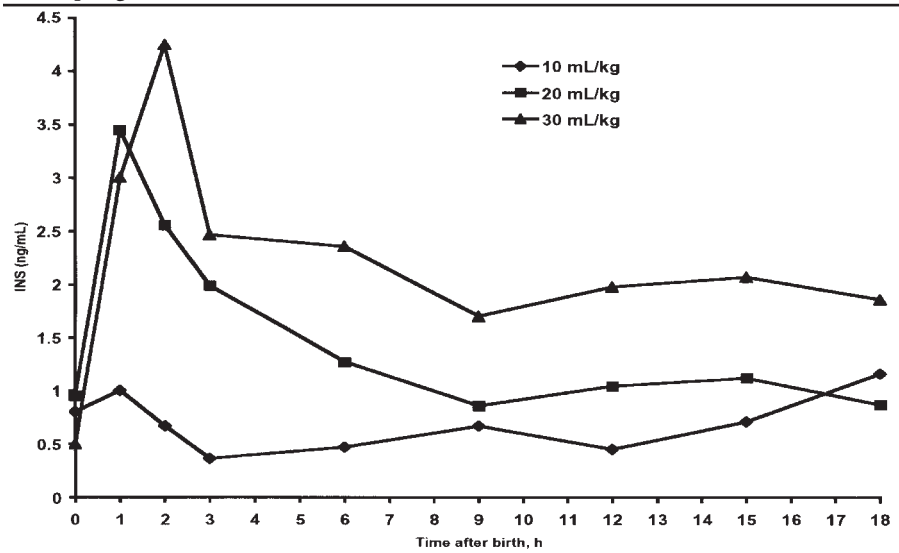

Figure 2. Serum insulin (INS) in lambs receiving 10 mL/kg, 20 mL/kg, and 30 mL/kg of body weight of colostrum from birth through hour 18. A treatment x time of sampling interaction was detected (P = .08). The pooled SE was .51 ng/mL.

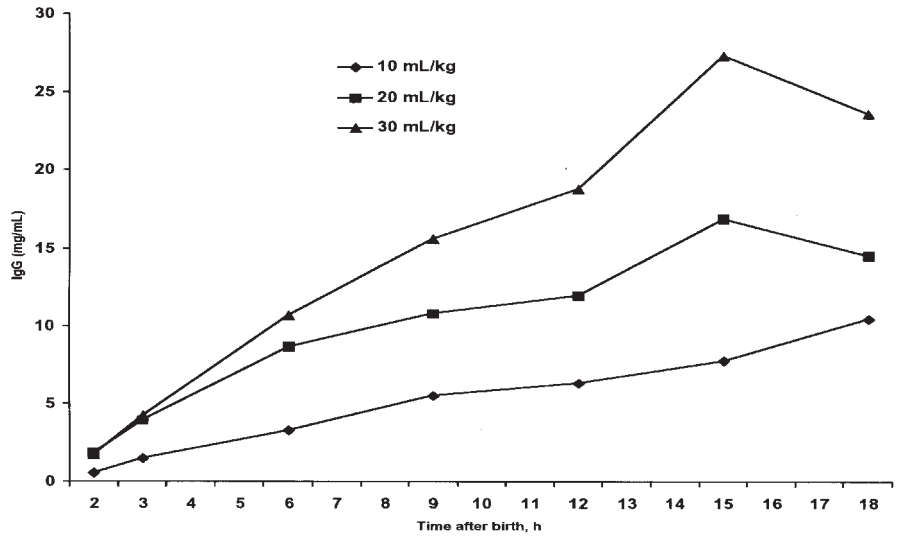

Figure 3. Serum immunoglobulin G (IgG) in lambs receiving 10 mL/kg, 20 mL/kg, and 30 mL/kg of body weight of colostrum every 3 hours from birth through hour 18. A treatment x time of sampling was detected (P = .002). The pooled SE was 1.03 ng/mL.

absorbed, if at all, in newborn calves. Prolonged colostrum feeding (six times instead of one) has been shown to cause greater IGF-1 concentrations in neonatal calves (Hammon and Blum, 1997). Neonates with a high plane of nutrition are also capable of producing more IGF-1 in the liver (Chestnutt and Wylie, 1995). As colostrum intake increased, the liver may have increased production of IGF-1.

Serum IgG concentrations in our study are similar to those reported by others (Klobasa et al., 1992; Mazzone et al., 1999). In calves between hours 0 and 24, IgG concentrations were greatest when fed larger amounts of colostrum sooner after birth (Stott et al., 1979b). Stott et al. (1979a) also found that age of calves at the first feeding had an inverse effect on the rate of IgG absorption. Lambs absorb IgG in the intestine up until the time of gut closure. The linear increase in serum IgG concentrations may reflect the cumulative effect of absorption of immunoglobulins after each consecutive feeding. This is in agreement with the theory that passive immunity of neonatal lambs is improved by multiple feedings of colostrum (Halliday, 1978). The increase in serum IgG concentrations is probably not evident until hour 6 some time is required after ingestion for nutrients to pass through the gastrointestinal tract and to be absorbed by the small intestine. Klobasa et al. (1992) noted greater serum IgG concentrations when lambs were fed at 4 to 6 hour intervals compared to 1 to 2 hour intervals between feedings.

A rise in serum INS followed the first feeding in all treatments in our study, however, a linear increase was observed as the amount of colostrum increased. Porter and Bassett (1979) reported INS increased 60 to 120 minutes after suckling in lambs 1 day old and older. The linear insulin rise associated with increased amounts of colostrum was likely the consequence of greater postprandial hyperglycemia with increased colostrum intake. Although there appears to be only one INS surge shown in Figure 2, blood samples were collected hourly only during the first 3 hours; subsequent INS surges might not have occurred due to the frequency of sampling after hour 3. In general, a linear increase in INS was noted at most sampling times as colostrum intake increased. Factors such as feeding

density, and energy and protein intake have been reported to modify insulin secretion (Guilloteau et al., 1997; Kühne et al., 2000).

Implications

Feeding increasing amounts of colostrum following birth influenced serum IgG, INS, IGF-1 and GH concentrations, thereby, influencing both passive immunity and endocrine status. Feeding between 20 and 30 mL/kg of BW of colostrum every 3 hours appeared to be beneficial to newborn lambs, resulting in high levels of serum IgG. Because no lamb mortality resulted from health problems during the first week of life and at weaning, even a minimal amount of colostrum (10 mL/kg of BW fed every 3 hours) seemed to provide an adequate source of nutrition, growth-promoting substances and IgG for neonatal survival the first week of life and through weaning.

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