Immunoglobulin Concentration, Specific Gravity, and Nitrogen Fractions of Colostrum from Jersey Cattle[1]

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ABSTRACT

Colostrum samples from 88 Jersey cows were analyzed for concentrations of IgG, IgM, IgA, total solids, specific gravity, and N fractions. Colostrum (50 ml) was sampled from each cow as soon as possible after parturition, and specific gravity was determined immediately using a hydrometer. Samples then were frozen prior to analysis of Ig, fat, and N fractions. Mean concentrations of IgG, IgM, and IgA were 65.8, 2.4, and 1.7 g/L, respectively. Concentration of IgG was lower, and IgA was higher, in colostrum from second lactation cows than from first lactation cows or from cows in third or later lactations; IgM increased linearly as lactation number increased. Total N, protein N, noncasein N, and fat contents also were lower in second lactation cows. Regression of total Ig (grams per liter) on specific gravity was $-1172 + 1180 \times$ specific gravity ($r^2 = .38$). Relationship of total Ig to specific gravity differed from colostrum of Holstein cattle and may have been related to differences in fat and noncasein N concentrations. Use of specific gravity hydrometer to estimate Ig concentration using equations derived from Holstein cattle appears to underestimate Ig concentration in colostrum from Jersey cattle.

(**Key words**: colostrum, immunoglobulins, Jersey)

Abbreviation key: SG = specific gravity.

INTRODUCTION

Acquisition of passive immunity by the neonatal calf depends on consumption of a sufficient mass of colostral Ig prior to cessation of macromolecular transport (closure) by the intestine (5). Mass of Ig consumed by the calf is determined by the amount of colostrum and concentration of Ig. Determination of colostral Ig concentration prior to feeding the calf would allow the producer to manage colostrum feeding and would optimize transfer of passive immunity. Fleenor and Stott (3) evaluated several components of colostrum to identify factors related to Ig concentration and determined that colostral specific gravity (SG) was correlated most highly with Ig content (r = .84). Subsequently, a hydrometer was developed to predict colostral Ig (3). Others (9, 11) also have determined a high correlation between colostral Ig and SG measurements.

Holstein cows (n = 29) were used by Fleenor and Stott (3) to determine the relationship between colostral Ig and SG. Differences in composition and greater SG of colostrum from Jersey cattle (13) may alter the relationship between colostral Ig and SG. Also, a paucity of data exists regarding Ig in colostrum from Jersey cattle (7, 10). Therefore, our objectives were to measure colostral Ig in Jersey cattle and to compare relationships among

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TABLE 1. Constituents of colostrum from Jersey cows.

Item	n	Minimum	Maximum	$\bar{X}$	SE
Ig, g/L					
Total	88	29.7	120.5	69.9	2.1
IgG	88	28.4	114.7	65.8	2.0
IgM	88	.3	8.2	2.4	.2
IgA	87	.4	4.5	1.7	.1
Total solids, %	86	12.8	36.6	23.6	.6
Specific gravity[1]	88	1.028	1.074	1.052	.001
N, g/L					
Total	88	9.16	31.63	23.56	.54
NPN	82	0	3.81	.85	.07
Protein[2]	82	8.63	30.57	22.57	.54
Casein	86	3.59	11.43	7.62	.21
Noncasein[3]	86	4.30	25.70	15.87	.49

[1]Measured with a hydrometer at approximately 37°C.

[2]Total N − NPN.

[3]Total N − casein N.

colostral Ig, total solids, SG, fat, and N components in first-milking colostrum from Jersey cattle.

MATERIALS AND METHODS

Experimental Design

Colostrum from Jersey cows (n = 96) was sampled as soon as possible after parturition. Calves were separated from the dam prior to nursing (n = 48) or were left with the dam (n = 48) for 72 h. When calves were separated from the dam, colostrum was completely hand-milked and mixed, and 50-ml samples were collected. When calves were allowed to suckle the dam, colostrum was hand-milked from all quarters to obtain 50-ml samples; however, colostrum from some suckled cows may have been consumed prior to sampling. Eight colostrum samples (four per treatment) that were mastitic, contained blood, or were otherwise abnormal were deleted from the data set. Therefore, data for 88 samples are reported. Cows were housed in a pasture until shortly after parturition.

Sampling and Analysis

The SG of colostrum was measured using a hydrometer calibrated for measurement of Ig in colostrum (Colostrometer™; Biogenics, Brookdale, CA). The regression equation of Fleenor and Stott (3) was used to determine SG. Measurement of SG was made at approximately 37°C.

Colostrum was frozen (−20°C) prior to analysis of IgG, IgM, and IgA by single radial immunodiffusion (VMRD, Pullman, WA), total N (Kjeldahl), NPN and casein N (15), and total solids. Samples were warmed to 30°C in a water bath and then dried at 100°C overnight to measure solids. Samples were cooled to room temperature (25°C) in a desiccator and weighed to the nearest .1 mg. Milk fat was analyzed by infrared analysis by the Tennessee DHIA laboratory. Unfortunately, colostrum was frozen prior to analysis of fat, which may have increased error in the analyses.

Statistical Analysis

Method of colostrum consumption (hand milked vs. suckled) and lactation number (1, 2, or ≥3) were analyzed as a randomized complete block design. Block, sex of calf, and interactions were included in the model. Significance at $P < .05$ was used unless otherwise noted. Relationships between colostral Ig concentration and colostral components were determined by regression analysis.

RESULTS AND DISCUSSION

Concentration of total Ig in colostrum averaged 69.9 g/L and ranged from 29.7 to 120.5

TABLE 2. Least squares means of concentration of Ig, total solids, specific gravity, and N fractions in colostrum from cows during the first, second, or third and later lactations.

	First		Second		Third and greater		Contrasts[1]	
Item	$\overline{X}$	SE	$\overline{X}$	SE	$\overline{X}$	SE	L	Q
n	34	...	21	...	33	...		
Ig, g/L								
Total	70.7	3.1	58.6	4.0	76.2	3.2	NS[2]	**
IgG	67.3	3.0	53.9	3.8	71.7	3.1	NS	**
IgM	1.9	.2	2.6	.3	2.8	.3	**	NS
IgA	1.4	.1	2.0	.2	1.7	.1	NS	*
N, g/L								
Total	24.51	.84	20.92	1.07	24.26	.85	NS	**
NPN	.73	.12	1.09	.15	.80	.12	NS	†
Protein N	23.36	.83	19.83	1.01	23.67	.85	NS	**
Casein N	8.17	.33	7.60	.42	7.06	.34	*	NS
Noncasein N	16.29	.76	13.32	.95	17.11	.77	NS	**
Total solids, %	24.8	.9	20.9	1.1	24.0	.9	NS	**
Specific gravity	1.053	.002	1.051	.002	1.052	.002	NS	NS

[1]Contrasts: L = linear, Q = quadratic effect of lactation.

[2]$P > .10$.

†$P < .10$.

*$P < .05$.

**$P < .01$.

g/L (Table 1). This concentration is lower than the total Ig of 9.0% in Jersey colostrum reported by Muller and Ellinger (10) but somewhat higher than the 6.4% reported by Kruse (7); however, means were from only 5 and 8 cows, respectively. Also, mean colostral Ig concentrations were greater than in reports from Holstein cows (3, 9, 10, 12, 14).

Colostrum contained more total N and N fractions than milk from Jersey cows (1). Total N concentrations compared favorably with colostral data summarized by Foley and Otterby (4) and Lomba et al. (8) but was higher than in other reports (3, 9, 12). Casein N constituted 32.3% of total N in our samples, which is somewhat lower than that reported by Fleenor and Stott (3); however, the amount of total Ig in their study also was lower, which would increase the proportion of casein N in their samples. Noncasein N, most of which is Ig, constituted over two-thirds of total N in all samples and was higher than in data of Fleenor and Stott (3) and Lomba et al. (8).

Allowing calves to suckle the dam did not significantly affect colostral Ig concentration compared with hand milking the dam, although Ig in colostrum from cows that were nursed was somewhat lower than Ig in colostrum from cows that were milked. This difference may be because several calves may have suckled cows prior to collection of the colostrum sample.

Average lactation number was 2.4 (SE = .2); the maximum was 7. Numbers of cows per lactation number were 34, 21, and 33 for first, second, and third and greater lactations, respectively. Lactation number affected colostral Ig concentration, fat, and N fractions (Table 2). Total Ig and IgG concentrations were lowest, and concentration of IgA was highest, in colostrum from second lactation cows. Colostral IgM increased linearly with lactation number. Total N, NPN, protein N, and noncasein N also were lower in colostrum from second lactation cows. Casein N declined linearly as lactation number increased. Other reports (2, 10, 14) of an effect of lactation number generally have supported an increase in Ig concentration as age increased; differences were greatest with cattle in the fourth or greater lactation. Pritchett et al. (14) also reported that cows in the second lactation had lower colostral Ig than older cows. No apparent reasons explain why colostrum from sec-

TABLE 3. Correlation coefficients[1] of colostral Ig, N fractions, total solids, specific gravity, and volume of colostrum produced.

	IgM	IgA	Total Ig	Total N	NPN	Protein N	Casein N	Non-casein N	Total solids	Specific gravity	Volume
IgG	.28	.13*	.99	.82	–.04*	.83	.12*	.88	.61	.63	–.19*
IgM		.28	.36	.17*	.17*	.09*	–.17*	.26	.05*	.14*	–.12*
IgA			.30	.21	–.03*	.12*	.09*	.19*	.11*	.07*	–.33
Total Ig				.82	–.03*	.82	.11*	.89	.60	.62	–.21*
Total N					–.02*	.99	.45	.92	.81	.69	–.23*
NPN						–.16*	–.02*	–.01*	–.05*	–.03*	.02*
Protein N							.49	.91	.80	.66	–.19*
Casein N								.07*	.41	.38	.08*
Noncasein N									.73	.61	–.27*
Total solids										.55	–.33
Specific gravity											–.20*

[1]n = 82 to 88, except volume, n = 43.

*$P > .05$.

ond lactation cows differs so markedly from colostrum from first lactation cows or from older cows.

Concentrations of total Ig and IgG were most highly correlated with noncasein N (Table 3), and correlations of total N and protein N also were high (Table 3). Correlations of total Ig and IgG with SG were lower than reports (9, 11) that correlated total Ig and SG (3) or IgG and SG. In our study, SG was more highly related to total N and protein N than was total Ig. Regression of total Ig on SG (Figure 1) indicated a significant positive relationship between colostral Ig and SG, but with considerable variation. Whether variation in SG was a function of method of analysis or differences in colostral composition is not clear. We measured SG with a hydrometer as soon as possible after sampling; standardization of colostral temperature, which influences SG (9), was not possible prior to measurement of SG. Regression analyses by Mechor et al. (9) indicated that for each degree of increase in colostrum temperature, the estimate of colostral Ig concentration using SG increased by .4 mg/ml. Although colostrum probably cooled somewhat after collection but prior to SG measurement, the extent of cooling probably introduced only a small error into the measurements. Two hydrometers were used during the study (one was damaged during use and was replaced); differences in calibration between the two hydrometers may have increased variation in SG measurements. Variation in colostral composition also may have influenced the relationship between SG and Ig. Albumin N (calculated as noncasein N – total Ig N – NPN) averaged 4.69 g/L of colostrum in our samples (CV = 52%). This mean is considerably higher and more variable than the 1.56 g of albumin protein/100 g of colostrum (CV = 35%) reported by Fleenor and Stott (3) but lower than data reported by Guidry et al. (6); Fleenor and Stott (3) calculated albumin N by the method of Rowland (15). We calculated globular N as total Ig N; therefore, our calculation of

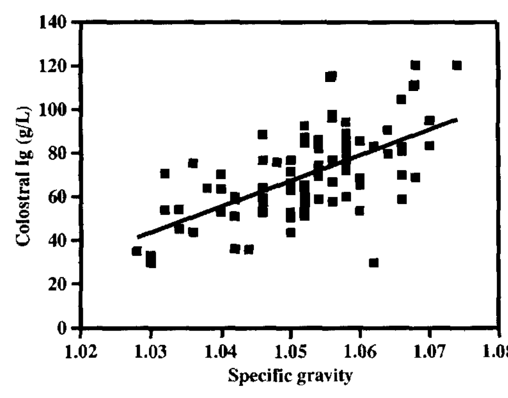

Figure 1. Relationship of total Ig in colostrum of Jersey cows and colostral specific gravity (Y = –1172 + 1180 × specific gravity; r^2 = .38).

TABLE 4. Regression coefficients of colostral constituents on colostral specific gravity and total Ig concentration.

	Specific gravity		Total Ig	
Item	Coefficient	*P*	Coefficient	*P*
Intercept	1.0163	.0001	15.9335	.0001
Total N, g/L	.0162	.0001		
Fat, g/L	–.0009	.02	–1.2073	.0147
Noncasein N, g/L			35.9455	.0001
r^2	.56		.77	

albumin N also contained non-Ig globular N and N in protease and peptones. Variation in albumin concentration in our samples may have affected colostral SG and, consequently, reduced correlation between SG and Ig. A positive correlation between SG and albumin ($r = .47$; $P < .01$) supported this proposition. Finally, Parrish et al. (13) reported that colostrum samples with large amounts of fat were associated with lower SG, although correlation between SG and fat was not reported. Mechor et al. (9) reported a negative correlation between fat and colostral SG ($r = -.57$; $P < .05$) using 39 Holstein cows. Colostral fat averaged 9.4% (SD = 4.4) in the study by Mechor et al. (9). Conversely, Fleenor and Stott (3) reported that fat was unrelated to SG ($P > .05$); colostral fat averaged 2.0% (CV = 105%) in their study. Fat percentages were 6.7 and 4.2%, respectively, for Holsteins and Jerseys (13). Variation in fat content of colostrum may have affected the degree to which fat influenced SG. Fat in our samples averaged 3.3% (SE = .2) and ranged from .1 to 8.7%. Stepwise regression of various colostral constituents on SG and total Ig concentration (Table 4) indicated that total N and fat percentage were the best predictors of SG and that noncasein N and fat were the best predictors of total Ig in colostrum. These data suggest that fat significantly influenced SG and, therefore, colostrometer readings. Further research is indicated to delineate more clearly the influence of colostral fat on colostrometer measurements.

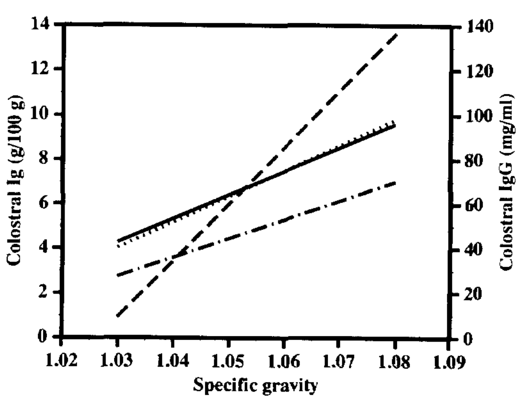

Figure 2. Regression of total colostral Ig on specific gravity by Fleenor and Stott [(3); - - -] and present study (—) on left axis and regression of colostral IgG by Mechor et al. [(9); — · —] and present study (. . .) on right axis.

Regression of total colostral Ig on SG (Figure 2) varied markedly from that reported by Fleenor and Stott (3). Differences in technique may, in part, account for different results. Fleenor and Stott (3) measured Ig by the method of Rowland (15), but we measured IgG by single radial immunodiffusion.

Slope of the regression of colostral IgG (milligrams per milliliter) on SG (1180; Figure 2) differed from slope of 853 reported by Mechor et al. (9). The equation of Mechor et al. (9) contained a coefficient for temperature, which was included as a constant (37°C) in Figure 2. Intercepts were –1172 for our study and –866 for the study by Mechor et al. (9). At a given SG, colostral IgG apparently was approximately 40% greater than that reported by Mechor et al. (9).

Relationship between SG and total Ig was significant in colostrum from Jersey cows but more variable than in other reports. Although the relationship between SG and Ig is similar to that in Holstein cows, colostrum from Jersey cows appears to contain a greater concentration of Ig.

REFERENCES

1 Cerbulis, J., and H. M. Farrell, Jr. 1975. Composition of milks of dairy cattle. I. Protein, lactose, and fat

contents and distribution of protein fraction. J. Dairy Sci. 58:817.

2 Devery-Pocius, J. E., and B. L. Larson. 1983. Age and previous lactations as factors in the amount of bovine colostral immunoglobulins. J. Dairy Sci. 66:221.

3 Fleenor, W. A., and G. H. Stott. 1980. Hydrometer test for estimation of immunoglobulin concentration in bovine colostrum. J. Dairy Sci. 63:973.

4 Foley, J. A., and D. E. Otterby. 1978. Availability, storage, treatment, composition, and feeding value of surplus colostrum: a review. J. Dairy Sci. 61:1033.

5 Gay, C. C. 1983. Failure of passive transfer of colostral immunoglobulins and neonatal disease in calves: a review. Proc. 4th Int. Symp. Neonatal Dis. Vet. Infect. Dis. Organ, Saskatoon, SK, Can.

6 Guidry, A. J., J. E. Butler, R. E. Pearson, and B. T. Weinland. 1980. IgA, IgG1, IgG2, IgM, and BSA in serum and mammary secretion throughout lactation. Vet. Immunol. Immunopathol. 1:329.

7 Kruse, V. 1970. Yield of colostrum and immunoglobulin in cattle at the first milking after parturition. Anim. Prod. 12:619.

8 Lomba, F., I. Fumiere, M. Tshibangu, G. Chauvaux, and V. Bienfet. 1978. Immunoglobulin transfer to calves and health problems in large bovine units. Ann. Rech. Vet. 9:353.

9 Mechor, G. D., Y. T. Gröhn, L. R. McDowell, and R. J. Van Saun. 1992. Specific gravity of bovine colostrum immunoglobulins as affected by temperature and colostrum components. J. Dairy Sci. 75:3131.

10 Muller, L. D., and D. K. Ellinger. 1981. Colostral immunoglobulin concentrations among breeds of dairy cattle. J. Dairy Sci. 64:1727.

11 Odde, K. G. 1988. Survival of the neonatal calf. Vet. Clin. North Am. Food Anim. Pract. 4:501.

12 Oyeniyi, O. O., and A. G. Hunter. 1978. Colostral constituents including immunoglobulins in the first three milkings postpartum. J. Dairy Sci. 61:44.

13 Parrish, D. B., G. H. Wise, J. S. Hughes, and F. W. Atkeson. 1950. Properties of the colostrum of the dairy cow. V. Yield, specific gravity and concentrations of total solids and its various components of colostrum and early milk. J. Dairy Sci. 33:457.

14 Pritchett, L. C., C. C. Gay, T. E. Besser, and D. D. Hancock. 1991. Management and production factors influencing immunoglobulin G_1 concentration in colostrum from Holstein cows. J. Dairy Sci. 74:2336.

15 Rowland, S. J. 1938. The determination of the nitrogen distribution in milk. J. Dairy Res. 9:42.