Colostral Constituents Including Immunoglobulins in the First Three Milkings Postpartum[1]

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ABSTRACT

Colostral changes in immunoglobulin (IgG), dry matter, ash, total protein, and whey protein were studied over the first three milkings postpartum. Immunoglobulin IgG concentration in colostrum from Holstein cows beginning their first, second, or third lactation was similar. However, older animals had more IgG in colostrum. Its rate of disappearance from colostrum was greater in younger animals. Dry matter, ash, total protein, and whey protein concentrations decreased from the first to the third milking (24 h) postpartum. Protein was the most variable constituent between cows at the same postpartum time.

INTRODUCTION

Passive immunization and neonatal nutrition effect calf survival; immunoglobulin measures both (11). Antibodies are transferred passively to the calf via colostral immunoglobulins on the first day of life (1, 4, 5, 7, 13, 20, 23, 32). Even though gut absorption of immunoglobulins ceases by 36 h postpartum, they still can function partially in the gut lumen to control bacterial populations during preweaning (21, 24). The principal immunoglobulin in bovine colostrum is IgG (7). Ingestion and absorption of IgG via colostrum are extremely important to the survival and well being of the newborn calf (12). Calf mortality is higher in Guernsey herds than in Holstein herds (14, 33). An objective of this paper was to determine if IgG in Holstein colostrum varied with lactation number. A second objective was to determine the change in IgG over the first three milkings postpartum.

Surplus colostrum is fed to reduce the cost of raising herd replacements during preweaning (1, 15, 25). Its composition changes continuously over the first 3 to 5 days of lactation toward that of normal milk (27, 30). Voluminous literature is available on specific composition changes during this period, but most of it is based on sample sizes of less than 15 cows (27). The final objective of this paper was to monitor compositional changes in Holstein colostrum over the first three milkings postpartum.

MATERIALS AND METHODS

Collection of Colostral Samples

Colostrum was collected during October to December from 71 Holsteins at the University of Minnesota Experiment Station for the first three milkings postpartum at 0, 12, 24 h. For representative samples of mammary secretion, calves were not allowed to nurse. Each udder was milked out as completely as possible by machine, and approximately 100 ml of the recovered colostrum were obtained for analysis. All samples were stored at −20 C.

Preparation of Colostral Whey

Whey was separated from casein by the ultracentrifugal technique of Podrazky et al. (29). Approximately 30 ml of colostrum were thawed and centrifuged for 60 min in a Beckman Type 42.1 Fixed Angle Rotor at 40 rpm (177,000 × *g*) with a Beckman Ultracentrifuge Model L5-50. An 18 gauge needle was pushed through the fat layer and centered approximately 6 to 9 mm above the casein pellet. Ten milliliters of whey were removed by syringe. The whey was stored at −20 C.

Chemical Analysis

Dry matter and ash content of whole colostral samples were determined according to A.O.A.C. (3) methods.

Samples were analyzed for protein by the

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Amido Black Dye Binding methodology of Weik et al. (34). Each sample (.25 ml) was in duplicate. If a spectrophotometric reading was less than 45% or more than 95%, a larger or smaller sample was run to fall within the most accurate range of the curve.

The IgG was assayed in whole colostrum by radial immunodiffusion both by commercial single radial immunodiffusion kits (Miles Lab. 64-472-1) and prepared plates (22) employing mono-specific antisera to bovine IgG. The assay accuracy was ± 10% within a range of .5 to 40 mg/ml serum. Whole colostrum samples were diluted to fall within that range.

RESULTS AND DISCUSSION

Part 1. IgG in Holstein Colostrum

Data for this part of the experiment are in Table 1. The mean concentration of IgG in Holstein colostrum decreased (P<.01) between the first milking postpartum and that at 12 h and 24 h postpartum. At 12 h postpartum, 78.3% of the initial IgG was present. At 24 h postpartum, 47.5% of the initial IgG was present. The amount of IgG in Holstein colostrum from cows beginning their first, second, or third lactation did not differ (P>.05). However, cows beginning their fourth through seventh lactation had more IgG in colostrum (P<.01). The rate of disappearance of IgG from colostrum was greater (P<.01) in the younger animals.

The bulk of colostral immunoglobulins are derived directly from plasma by active transport across the alveolar epithelium (2, 6, 7, 18) rather than by synthesis in the gland. This mechanism is highly selective in the bovine, as IgG_1 is transported to a much greater extent than IgG_2 (8). Therefore, IgG should be a good constituent in colostrum for determining immunoglobulins as it makes up 86% of the total Igs in colostrum. Bovine colostral IgM and IgA each make up 7% of the total immunoglobulins in colostrum (7).

Butler et al. (8) showed that generalizations about immunoglobulin quantities could be misleading if they were based on data from a few animals of a single breed or on samples that were pooled from various sources. Data in this paper were based on individual samples from a large number of animals (71 Holsteins). In addition, each sample was an aliquot of the entire milking rather than a quarter sample. Hence, the value reported should represent the population of cattle sampled in Minnesota.

Butler et al. (8) reported mean IgG of 17 mg/ml in colostral whey at calving. Their data were based on Holstein colostral whey samples, while this study reports data on the whole colostrum. Klaus et al. (16) found 43.2 ± 14.0 mg IgG/ml in colostral whey from 10 dairy cows sampled prior to suckling. Kruse (17) reported significant differences among breeds in the concentration of colostral immune globulins. Wilson et al. (35) reported mean colostral IgG of 37.5 mg/ml for three Jerseys. Penhale and Christie (28) reported mean colostral IgG

TABLE 1. Mean IgG concentrations (mg/ml) in colostrum from the first three milkings postpartum.

Lactation cow beginning		IgG in colostrum[a] from: Initial milking (0 h) $\bar{X}$	SE	Second milking[b] (12 h) $\bar{X}$	SE	Third milking[c] (24 h) $\bar{X}$	SE
First	(28)	29.8	2.4	23.5	2.3	14.3	2.0
Second	(22)	30.5	3.3	22.4	3.0	11.4	1.8
Third	(10)	33.9	3.4	26.6	3.3	16.8	3.2
Fourth–seventh	(11)	41.6	6.1	36.3	5.6	24.9	3.9
First–seventh	(71)	32.4	1.8	25.4	1.6	15.4	1.3

[a]In mg/ml colostrum.

[b]Values are different (P<.01) from initial value by Student's t-test.

[c]Values are different (P<.01) from 12 h by Student's t-test.

Number of cows given in parentheses.

of 24.1 mg/ml for 20 Ayrshires. Johnson and Harpestad (14) found that calf mortality was higher in Guernsey (18.2%) herds than in Holstein herds (13.1%).

Part 2. Dry Matter, Ash, Total Protein, and Whey Protein in Colostrum from the First Three Milkings Postpartum

Data for this part of the experiment are in Table 2. Variation was considerable in all constituents collected from cows at the same postpartum period. Dry matter, ash, total protein, and whey protein decreased ($P<.01$) between the first milking postpartum and 12 h and 24 h postpartum.

Colostrum has a high content of total solids compared to normal milk (25% vs. 13%). Similar values have been reported by others (9, 27, 30). The colostral solids are rich in protein. Usually far more colostrum is produced than a calf can consume, and it is stored for later consumption. Parrish et al. (27) reported that, based on equal weights of dry matter, milk had a similar energy value to colostrum. Therefore, when colostrum is diluted with water to the total solids content of milk, 50 kg colostrum would be equivalent on an energy basis to approximately 100 kg milk. Therefore, properly managed colostrum can decrease significantly the cost of raising heifers to weaning age.

The dry matter (total solids) in colostrum consists essentially of protein, carbohydrate (mainly lactose), fat, minerals (ash), and vitamins (31). These nutrients are needed for the survival of the newborn until it is weaned. The amount of dry matter in colostrum would have an effect on the movement of water in the digestive tract of the suckling calf. Since gamma globulins are absorbed intact from colostrum to blood during the first day after suckling, water from intestinal cells may be replacing the absorbed protein. The high total solids concentration would make this osmotic shift possible. In addition, the concentration of lactose is lower in colostrum than normal milk (9, 27, 30, 31). This difference is an advantage because lactose can induce the young to scour (diarrhea) with subsequent death or unthriftiness (26, 31).

Our data for ash were similar, although more variable, to those reported by Parrish et al. (27) for 10 Holstein cows. The composition of milk ash is mainly K, Ca, Na, Mg, and Fe as cations

TABLE 2. Mean milk constituents in colostrum from the first three milkings postpartum.[a]

Time and milking postpartum	Colostral constituent							
	Dry matter		Ash		Total protein		Whey protein	
	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
0 h, initial	24.96	.68	1.12	.04	11.49	.63	11.01	.66
12 h, second[b]	21.13	.77	1.07	.03	9.40	.40	9.05	.45
24 h, third[b,c]	16.91	.61	.96	.02	7.04	.40	4.85	.36

[a]In g/100 ml, n = 45 Holsteins.

[b]Values are different ($P<.01$) from initial value by Student's t-test.

[c]Values are different ($P<.01$) from 12 h value by Student's t-test.

and P, Cl, and S an anions. Garrett and Overman (10) showed that Ca, Mg, Na, Cl, and P were high at parturition and during the early hours of lactation but rapidly declined towards a fairly constant level as the milk became normal. Calcium and phosphorus are needed for development of bones and teeth. In addition to its function as a major constituent of the bones, phosphorus is involved in energy metabolism and many other metabolic functions. Chloride is the major anion that determines the tonicity of milk.

Colostrum selected 12 and 24 h postpartum contained only about 84% and 64% as much protein/ml as that secreted at calving time. Parrish et al. (27) reported lower figures of about 60% and 36% for similar times.

The dairy cow tends to reach a maximum production for milk and fat about a month after parturition. However, protein synthesis does not behave similarly. Larson and Kendall (19) showed that total protein was highest in the first milk and it decreased as days of lactation increased. It decreased from about 1200 g to 700 g after 1 day of lactation. This was 58% as much as was secreted at calving time. This percentage compares closely with 64% reported above for the reduction after 1 day of lactation.

One of the contributions of this paper to the vast amount of information on colostrum is that it confirms several previous studies that did not have sufficient numbers to make statistically valid conclusions.

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