Practical Colostrum Evaluation

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Introduction

Provision of high quality colostrum is an essential feature of a successful calf rearing program, providing immunoglobulins, non-antibody immune factors, protein, energy, fat, vitamins and minerals. A successful colostrum feeding program reduces calf mortality to less than 5%, improves resistance to enteric disease and promotes weight gain the first four days of life. Careful evaluation of several important aspects of a colostrum feeding program is essential when these goals are to be achieved.

Colostrum, which is produced by cattle beginning approximately 5 weeks prepartum and ending at calving, is much higher in total solids than milk (22% solids compared to 12% in milk). Most of the difference in solids is due to an increased percentage of protein (17.6% protein compred to 3.3% in milk). Almost half (47%) of the total protein of colostrum is gamma globulin. While the immunoglobulins are the most important component of colostrum and the substance upon which evaluation is based, other non-antibody factors such as complement, lactoferrin, transferrin, lysozymes, lactoperoxidase, thiocyanate, hydrogen peroxide, lymphocytes, and bacterial flora serve important local and systemic immune functions.[1] In addition, casein, lactose, fat, vitamins A and E, titratable acidity, and electrolytes play an important role in establishing normal digestive function and give nutritional value to colostrum. These latter factors continue to be of benefit to the calf after gut closure has occurred and are part of the reason that colostrum feeding has been advocated until weaning in calves. Colostrum also has 1000 times more gammaglutamyl transferase (GGT) than serum. While the enzyme is not bound to immunoglobulins, its concentration is highly correlated with total protein concentration and immunoglobulin concentrations.[2] Although GGT has not been used to routinely evaluate colostral quality or absorption, it may be of some benefit in this regard.

Evaluation of Colostrum

Immunoglobulin Mass

The immunoglobulin mass is the product of immunoglobulin concentration and the volume of colostrum and is the most important determinant of the calf's immunoglobulin concentration. Volume and concentration are important when calves are allowed to suckle naturally. In artificial rearing, the volume of colostrum can be controlled. In most situations, however, the volume of colostrum is not a limiting factor, with the exception of first-calf heifers, especially when they have been on a marginal nutritional plane.[3,4] Nutrition affects colostral volume more than immunoglobulin concentration.[4] Heifers may have only 65% of the immunoglobulin concentration of third lactation and older cows. Dairy heifers, however, generally produce an adequate volume of colostrum to provide sufficient immunoglobulin mass, whereas some beef heifers may produce as little as 750 ml of colostrum.[5,6] The average colostral volume produced by beef cattle is approximately 3 L whereas the American Holstein produces a much larger volume.[4,7] Dairy cattle tend to have a lower immunoglobulin mass than beef cattle, however, which may be due to less selection for dairy cattle with good colostral quality. An immunoglobulin mass of between 200 and 300 g is required for successful passive transfer of immunoglobulin to calves; for most Holsteins, a volume of 3 to 4 L of high quality colostrum would be required to achieve this.

The immunoglobulin mass decreases to two-third and one-third of the original mass by 6 and 24 hours after the first milking, respectively.[8] Delaying the first milking does not delay the dilution of immunoglobulin content, which is significant if the first milking is delayed by more than 9 hours. Successful passive transfer of immunoglobulins is best correlated with first colostrum gammaglobulin concentration as well as the total amount of gammaglobulin fed.[9] There is wide variability amongst cattle in immunoglobulin content of colostrum but the amount is repeatable from one lactation to another, suggesting that it is genetically determined.

A successful colostrum feeding program is based on feeding colostrum with an immunoglobulin content greater than 60 mg/ml, an IgG_1 concentration greater than 30 mg/ml, or a total protein content of whey greater than 120 g/l.[10,11] While these values give specific information about immunoglobulin content of colostrum, they require specialized laboratory tests and time for determination. A simplified cowside estimation of colostral immunoglobulin content can be obtained immediately using a hydrometer.[12] Colostrum with a specific gravity greater than 1.050 meets the requirements listed above and is considered good quality colostrum.

In order to maximize the immunoglobulin mass fed to calves, feed only good quality colostrum and feed adequate volume to assure passive transfer of immunoglobulins. Select cattle which produce colostrum with a specific gravity greater than 1.050 and feed adequate energy and protein during the dry period to assure that optimal volume of colostrum is produced. Obtain colostrum from cattle prior to 9 hours after parturition. Feed colostrum from first-calf heifers after calves are 24 hours of age.

Age at First Feeding

The time of the first feeding determines the efficiency of immunoglobulin absorption. It is most efficient 2 to 6 hours after birth. By 9 hours after birth, a calf can absorb only 50% of the immunoglobulin it was capable of absorbing at 1 hour of age and closure is complete at approximately 24 hours of age. Withholding food does not improve the efficiency of absorption or significantly delay gut closure.

Left unattended, many calves fail to suckle by 6 to 8 hours after birth, especially if handled or stressed.[7,13.] Therefore, calves artificially reared or handled immediately after birth should be fed prior to 6 hours of age with a sufficient volume of high quality colostrum. Stored colostrum is most efficient because preparing and milking the dam prior to feeding the calf frequently results in a delay of the first feeding.

The second feeding of colostrum is also important in that it increases the immunoglobulin mass available for and improves efficiency of absorption. Absorption efficiency may be improved by displacement of the first feeding to the intestinal absorptive sites. The second feeding should occur while absorptive capacity is still efficient. Therefore, a second feeding prior to 12 hours of age is desirable.

Volume of Colostrum

Aim to feed 10% of the calf's body weight by 12 hours of age. For a 45 kg calf, at least 4.5 L of colostrum should be fed. This volume of colostrum does not overwhelm absorptive mechanisms and will not cause serious side effects or diarrhea. The larger volume assures that an adequate immunoglobulin mass is presented to the intestine. While some calves have been shown to voluntarily consume up to 6 L of colostrum at the first feeding, the average level of ingestion for most breeds is less than this amount.[9] Calves that do not voluntarily suckle the full amount should be force fed the remaining volume by esophageal feeder or stomach tube. The efficiency of absorption is slightly reduced by feeding large (1/L/kg) volumes and force feeding, but this level insures adequate passive transfer. For the American Holstein, it has been recommended that 2.5 to 3.0 L be fed in the first 2 hours followed by an additional 1.5 to 3.0 L at 12 hours of age.[3,7] The larger volumes should be fed when force feeding and in cold weather.

Route of Administration

Natural suckling of colostrum can be highly successful in beef cattle but is associated with a high prevalence of failure of passive transfer of immunoglobulins in dairy cattle. The reasons for this failure may be lack of selection pressure for dairy cattle which produce high quality colostrum, failure of dairy calves to ingest adequate volume early enough in life due to poor sucking drive, poor mothering instinct and large udders with teats too close to the ground. Even with beef cattle, intervention is beneficial for calves which are weak, hypothermic, or rejected, or when the dam is ill, has mastitis or is known to have leaked colostrum prior to calving.

Absorption of colostral immunoglobulins is most efficient when the calf suckles naturally, since closure of the eosphageal groove results in more rapid delivery to the absorptive sites. Some calves require training to suckle from nipple buckets or pail, which results in delay of the first feeding. The first feeding can also be protracted and inefficient in calves which suckle poorly. In these instances force feeding of colostrum by esophageal feeder or stomach tube is desirable. While the efficiency of absorption is reduced with force feeding, the large volume presented insures an adequate immunoglobulin mass and negates the effect of the residual amount left in the rumen. Many calves will require a combination of suckling and force feeding any of the required volume which was not suckled.

Miscellaneous Factors

In evaluating the colostrum feeding program, it is important to assess colostral cleanliness. In one survey, less than 60% of managers cleaned the udders prior to milking colostrum.[14] The dam should be adequately prepared for milking and the colostrum stored or fed from closed and sanitized containers. There is a beneficial effect on the absorption of colostral immunoglobulins from the presence of the dam even if calves do not suckle naturally. Calves fed artificially should be left with the dam as long as is practical. In addition to cold stress, hot weather will reduce the efficiency of absorption of immunoglobulin. Therefore, larger volumes of colostrum should be fed to calves stressed by heat or cold.

Colostral pooling has been advocated as a method to average out the wide individual variability in immunoglobulin mass. However, values for immunoglobulin concentration in pooled colostrum are invariably lower than individual cows because of the dilution effect of the larger volume. For this reason, pooling of colostrum is only effective if colostrum with specific gravity greater than 1.050 is saved. Generally, a more effective practice is to freeze individual cow colostrum which has an acceptable specific gravity to be used as needed.

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Storage of high quality colostrum allows producers to have a ready source of immunoglobulins available to feed calves within an hour or two of birth. Storage of an adequate volume of high quality colostrum prevents delayed first feeding associated with preparation and milking of the dam. Refrigeration and freezing are the best methods of storing but are the most expensive and inconvenient. In one survey, less than 25% of farms used frozen colostrum.[14] Refrigerated colostrum should be used within 7 days while frozen colostrum can be stored for much longer periods of time provided containers are clean and closed. Untreated colostrum stored at room temperature should be used within 2 days. Chemical preservation of fresh colostrum has been achieved using K—sorbate in a final concentration of 0.5%. Storage of the chemically preserved colostrum for up to 2 weeks at room temperature and 3 months refrigerated did not impair quality.[15]

Assessment of Passive Transfer

The final step in evaluating the colostrum feeding program is assessment of passive transfer in calves. Calf survival and prevalence of disease in the neonatal period is directly related to serum immunoglobulin concentration. Passive transfer of immunoglobulins is considered successful when the concentration is greater than 1200 mg/dl. Immunoglobulin concentrations between 500 and 1200 mg/dl represent partial failure of passive transfer. If the concentration of IgG is less than 500 mg/dl, IgM less than 80 mg/dl, or IgA less than 22 mg/dl, failure of passive transfer is complete.

There are many tests available for quantitative or semi-quantitative assessment of passive transfer. All tests require separation of serum before initiating the test and are ideally performed between 2 and 7 days of age. The test which serves as the gold standard for accuracy and to which all other tests are compared is the radial immunodiffusion test. This test employs specific antibovine immunoglobulin and is available as a kit. The test is the most expensive of all the tests to run and requires 24 hours before results can be read accurately. There are several tests which are less expensive to run and which provide almost immediate semi-quantitative estimate of serum immunoglobulin concentration in calves.

The zinc sulfate turbidity test is performed using 6 ml of zinc sulfate solution and 1 ml of serum. The zinc sulfate solution is made using 205 mg zinc sulfate and 1 L of boiled distilled water which is stored in an airtight container or a container with a soda lime trap to prevent Co_2 contamination. The presence of immunoglobulins is demonstrated by turbidity, which begins at a concentration of 400 mg/dl. The test can be specifically quantitated using a colorimeter and standardized reference samples of known immunoglobulin concentrations. More commonly, the level of immunoglobulin is estimated based on the turbidity. The presence of turbidity does not indicate that passive transfer is successful since it occurs at a low immunoglobulin concentration. Turbidity sufficient to obscure newspaper print or similar to the dam in a test run simultaneously is considered to be evidence of successful passive transfer. The results can be falsely positive if the calf is dehydrated.

The sodium sulfite test provides more accurate estimation of immunoglobulin concentration. This test requires three solutions of 14, 16, and 18% sodium sulfite. The test is performed with 1.9 ml of each of the sodium sulfite solutions and 0.1 ml of serum. Turbidity in none of the tubes or just the 18% solution means that there is less than 500 mg/dl (failure of passive transfer) of immunoglobulin. Turbidity in the 16 and 18% solutions only indicate a level of immunoglobulins between 500 and 1500 mg/dl (partial failure of passive transfer), and turbidity in all 3 tubes indicates an immunoglobulin concentration greater than 1500 mg//dl (successful passive transfer).

The refractometer can also be used to estimate immunoglobulin concentration. The best results are obtained if the total protein concentration at 24 to 48 hours of age can be compared to the value determined before nursing. In most calves, a total protein concentration below 5 g/dl indicate failure of passive transfer, while values greater than 6 g/dl are indicative of adequate transfer of immunoglobulins. Values between 5 and 6 g/dl are difficult to interpret. These guidelines are based on a standard presuckle level of total protein and assume that the calf is normally hydrated.

It is likely that elevated levels of serum GGT in calves is indicative of colostrum absorption and is correlated with the serum concentration of immunoglobulins. Guidelines for concentrations which are indicative of failure and successful passive transfer have not been established.

Summary

Evaluation of a colostrum feeding program has many steps. Of most importance is the feeding and proper storage of high quality colostrum (specific gravity > 1.050). Colostrum should be fed at a level approximately 10% of body weight in the first 12 hours of the calf's life. The first feeding should be given by 2 hours of age. The colostrum that is not suckled should be force fed. The final step in evaluation of the colostrum feeding is a rapid, cost-effective estimation of the calf's immunoglobulin concentration, which can be done by zinc sulfate turbidity or sodium sulfite precipitation test, or refractometer.

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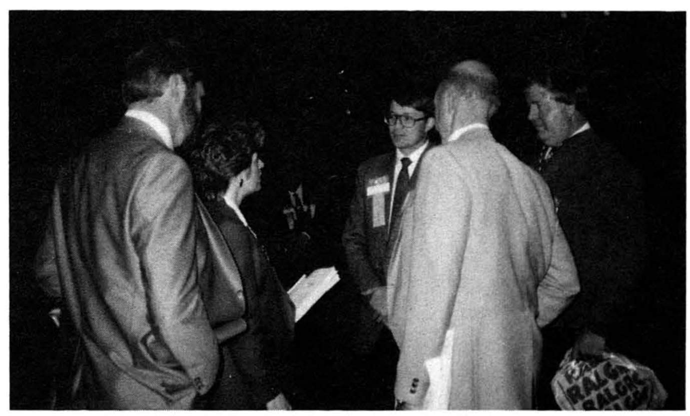

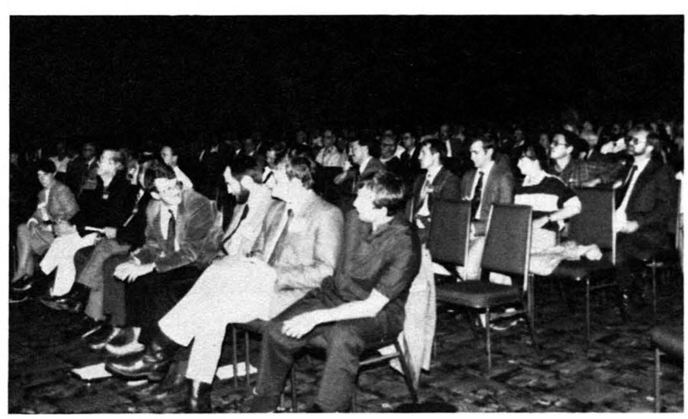

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