Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Efficacy of a Dried Colostrum Powder in the Prevention of Disease in Neonatal Holstein Calves

WOLFGANG ZAREMBA, WALTER M. GUTERBOCK, and CHARLES A. HOLMBERG
Veterinary Medicine Teaching and Research Center
University of California-Davis
Tulare 93274

ABSTRACT

The efficacy of a dried colostrum powder, DCW Concentrate™, as a colostrum supplement or substitute was tested using four groups of 15 calves. Physical condition and IgG status were examined during the first 30 d of life. Calves were fed the dried colostrum powder (group A), pooled colostrum (group C), or both (groups B and D) 2 h after birth. Calves fed 85 g of the dried colostrum powder dissolved in 3 kg of whole milk (group A) had significantly lower IgG concentrations 24 h after birth than calves of the other groups. Administration of 85 g of the dried colostrum powder plus 3 kg of colostrum (group C) did not lead to significantly higher IgG concentrations 24 h after birth than did administration of 3 kg of colostrum alone (group B). Calves fed 85 g of the dried colostrum powder plus 1.5 kg of colostrum (group D) had an IgG concentration at 24 h of age that was not significantly different from that of calves given 3 kg of colostrum (group B). Morbidity and mortality rates were not significantly different among groups. One calf died in each of groups A and B; no losses occurred in groups C and D. Body weight increase was not significantly different among groups.
(**Key words**: dried colostrum powder, immunoglobulins, calf diseases, prevention)

Abbreviation key: **DC** = dried colostrum powder (DCW Concentrate™).

INTRODUCTION

Calf diseases and losses have always been and still are important veterinary and economic problems. The relationship between neonatal morbidity or mortality and failure of passive transfer of Ig has been demonstrated in numerous epidemiological studies (2, 3, 13, 15). One of the most important ways to reduce calf morbidity and mortality is the early administration of adequate amounts of Ig in colostrum. Calves may not receive adequate amounts of Ig if the dam's colostrum is not of sufficient quality or quantity or if fresh or frozen colostrum from another cow is not available. The purpose of this study was to test the value of a commercial dried colostrum powder, DCW Concentrate™ (**DC**; Smarte International, Inc., Calgary, AB, Canada) as a colostrum supplement or substitute.

MATERIALS AND METHODS

Procedure

Sixty healthy Holstein bull calves were assigned randomly at birth to one of four groups; each group contained 15 calves. Calves with BW of 40 kg were fed by esophageal tube 2 h after birth as follows: group A, 85 g of DC dissolved in 3 kg of whole milk; group B, 3 kg of colostrum; group C, 85 g of DC dissolved in 3 kg of colostrum; or group D, 85 g of DC dissolved in 1.5 kg of colostrum and 1.5 kg of whole milk.

As the BW of a particular calf varied from 40 kg, the amount fed was altered as described by Binder (1), according to the formula

$$M_z = (KGW_z^{.75} \times M_y)/(KGW_y^{.75}$$

where M_z = amount of colostrum or DC administered to a 40-kg calf, M_y = actual amount

Received July 22, 1992.
Accepted November 6, 1992.

of colostrum or DC administered, KGW_z = BW of a 40-kg calf, and KGW_y = actual BW of the calf. All feedings thereafter were 3.8 kg/d of whole milk from the bulk tank, divided into two feedings. Blood was drawn from the calves for evaluation of IgG immediately after birth and at 24 h and d 30 after birth. During the first 30 d of life, the clinical status of the calves was monitored at least twice daily. All calves were weighed at birth and at d 30 after birth. Dead calves were necropsied.

Location and Facilities

The trial was conducted at a 2000-cow dairy farm in Tulare County, CA; total herd size was 4000, and calf mortality averaged 8.1% during the previous 12 mo.

Dams

Dams were housed in straw-bedded maternity pens and were under observation during calving. All dams were free of any disease detrimental to the health of the fetus or newborn, and dams calved without any type of assistance. Dams with induced parturition or multiple pregnancies were excluded from the study.

Criteria for Selection of the Calves

The following criteria were used to select healthy and mature calves: 7 to 8 Apgar score (20) immediately after birth, normal breathing during the 1st h of life, gestation age 275 to 285 d, BW greater than 30 kg; at least six temporary incisors partially broken through gums, umbilical hairs of normal length, and no functional abnormalities. Only male Holstein calves were selected.

Clinical Examination of the Calves

During the 1st h of life, calves were examined thoroughly to eliminate newborns with asphyxia. Immediately after delivery, birth-related asphyxia was excluded by the Apgar scheme (20). With the Apgar scheme, movements of the head as a reaction to cold water shower, eye lid and claw reflexes, respiration, and color of the mucous membranes were evaluated. Each of these viability signs was scored from 0 to 2, and the sum of single scores for each parameter was a measure of the degree of viability. According to this scheme, "viable" calves had scores of 7 to 8 points (minimum criterion for selection for the study). Calves "at risk" had scores of 4 to 6 points. "Weak" newborns were scored 0 to 3 points. Thirty and 60 min after birth, calves were examined; special consideration was given to abnormalities of the respiratory system to exclude calves that developed respiratory distress syndrome during the 1st h after delivery. For the remainder of the study, the clinical status of the calves was monitored continuously by general and, if necessary, by special examination at least twice daily.

Illnesses observed in the trial calves were classified clinically as follows: diarrhea was diagnosed as watery consistency of feces. Other signs of disease were not required for the diagnosis of diarrhea. Cases of diarrhea were categorized as slight (general health not or slightly disturbed; no signs of dehydration) or severe (general health moderately or severely disturbed; signs of dehydration).

Calves were classified as having pneumonia when respiratory rate or movement was abnormal and when auscultation revealed abnormal sounds.

Treatment of Calves

Diarrhea. Calves with diarrhea were given electrolytes (60 g; D-Electrolyte™; Walco Int., Inc., Porterville, CA) and Kaolin-Pectin Anti-Diarrheal Liquid™ (40 ml; Durvet, Inc., Blue Springs, MS) dissolved in 1.9 L of whole milk twice daily until diarrhea was cleared. If the calves showed symptoms of severe dehydration (sunken eyes, extreme reduced skin elasticity), they were treated with 1 L of .9% NaCl solution administered i.v. at least once. In diarrheic calves for which the general health was moderately or severely disturbed, gentamicin (4 mg/kg of BW) was injected i.m. twice daily for a minimum of 3 consecutive d.

Pneumonia. At the first signs of pneumonia, calves were treated i.v. with oxytetracycline (10 mg/kg of BW daily) for a minimum of 3 d.

Housing and Feeding of the Calves

In the first 36 h of life, the trial calves were housed in separate hutches close to the mater-

TABLE 1. Morbidity and mortality rates of calves during the first 30 d after birth.[1]

Group[2]	Morbidity	Mortality	Diarrhea		Pneumonia
			Slight	Severe	
A	3	1	2	1	0
B	2	1	1	1	0
C	2	0	1	1	0
D	3	0	1	1	1

[1]No significant differences among the groups ($P > .05$).

[2]Group A, 85 g of dried colostrum powder (DC; DCW Concentrate™; Smarte International, Inc., Calgary, AB, Canada); group B, 3 kg of colostrum from a first colostrum pool; group C, 85 g of DC plus 3 kg of colostrum from a first colostrum pool; group D, 85 g of DC plus 1.5 kg of colostrum from a first colostrum pool. There were 15 calves per group.

nity pens, which permitted the complete control of Ig supply and grouping of the calves. Thereafter, the calves were moved to hutches in a designated row for the trial in the regular calf housing area. The calves were put on the usual milk feeding system for the dairy at 12 h of age. This system consisted of 1.9 L of lukewarm whole milk twice daily by nipple bottle. All sick calves that were unable to drink on their own were tube fed. Beginning at 9 d of age, a calf starter grain mix was offered for ad libitum intake.

Colostrum Pool

Colostrum from the first milking of 10 multiparous Holstein cows was collected by machine and pooled in a large container. The udder health of the donor cows was evaluated by clinical and bacteriological examination. Only colostrum from cows with a high Ig content based on colostrometer testing as described by Fleenor and Stott (6) was used. The pooled colostrum was put into 1-L plastic bags and stored at −18°C. When needed, the frozen colostrum was thawed at 39°C in a water bath.

Determination of Total IgG

Concentration of IgG in blood serum, colostrum, and DC was determined by single radial immunodiffusion with commercial kits (IgG SRID Kit; VMRD, Inc., Pullman, WA).

Statistical Analysis

At each period, an ANOVA was performed to compare serum IgG concentrations and BW of calves in the four treatment groups. For comparison among individual group means, Scheffe's multiple comparison procedure was used for each period, and significance was determined at 5%. Changes over time in the individual group means were tested for significance (from zero) by paired comparison *t* test using the Bonferroni method to keep experimental significance below 5% for all eight comparisons. The frequency distributions for morbidity and mortality were compared by means of Fischer's exact test.

RESULTS

Morbidity and mortality data on calves during the first 30 d are presented in Table 1. Clinical disease of the trial calves was characterized by diarrhea of varying severity and by pneumonia. No other common clinical syndromes of the newborn calf were observed. Calves in group A did not have morbidity or mortality significantly different from those of calves from group B. Administration of DC plus two levels of colostrum (groups C and D) did not lead to a better clinical outcome than administration of colostrum alone or DC.

The calves that died, one in group A (at 11 d of age) and one in group B (at 30 d of age, shortly after being weighed and bled), had severe diarrhea with marked dehydration. Gross necropsy and histological examinations on the major organ systems revealed no unique lesions other than acute enteric disease. Culture for *Salmonella* sp., fluorescent antibody staining for *Rota* and *Corona* viruses, epithelial adherent *Escherichia coli,* and fecal examination for *Cryptosporidia* sp. were negative in both calves.

TABLE 2. Body weights of the calves.[1]

Group[2]	Immediately after birth		At 30 d after birth		Average increase in BW	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
	(kg)					
A	41.5	6.4	50.4	6.8	8.9	1.3
B	41.5	6.1	50.5	6.6	8.9	1.4
C	41.2	6.2	50.4	6.7	9.2	1.3
D	41.4	5.9	50.4	6.3	8.9	1.4

[1]No significant differences among the groups ($P > .05$).

[2]Group A, 85 g of dried colostrum powder (DC; DCW Concentrate™; Smarte International, Inc., Calgary, AB, Canada); group B, 3 kg of colostrum from a first colostrum pool; group C, 85 g of DC plus 3 kg of colostrum from a first colostrum pool; group D, 85 g of DC plus 1.5 kg of colostrum from a first colostrum pool. There were 15 calves per group. One calf in group A died 11 d after birth.

The BW from the calves of the four groups are presented in Table 2. On d 1 and 30 after birth, the comparison of the BW did not reveal significant differences among groups. The average increase in BW was about 9 kg in 30 d in each group.

The serum concentrations of IgG from the calves of the four groups are shown in Table 3. Immediately after birth, IgG concentrations were not significantly different among groups. Twenty-four hours after birth (i.e., 22 h after treatment), the increase of IgG concentrations was significant in all four groups. At this time, calves treated with DC in whole milk (group A) had a mean IgG concentration that was significantly lower than those of the other three groups. The 85 g of DC plus 3 kg of colostrum (group C) 24 h after birth did not lead to IgG concentrations significantly higher than 3 kg of colostrum alone (group B). Calves fed with 85 g of DC plus 1.5 kg of colostrum (group D) demonstrated a mean IgG concentration at 24 h after birth that was not significantly different from that of calves given 3 kg of colostrum (group B) but that tended to be numerically lower. However, at 24 h after birth, calves of group D showed a mean IgG concentration that was significantly lower than that of calves fed 85 g of DC plus 3 kg of colostrum (group C). For the two groups with the highest mean IgG at 24 h after birth, groups B and C, IgG concentrations decreased

TABLE 3. Concentrations of IgG in serum.

Group[1]	Immediately after birth		At 24 d after birth		at 30 d after birth	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
	(mg/100 ml)					
A	121.8^{a}	82.1	254.5^{A}	40.6	302.9	100.7
B	122.5^{a}	94.8	$775.5^{bc,A}$	325.3	$513.6^{d,A}$	457.8
C	140.7^{a}	110.3	$980.3^{b,A}$	470.6	754.4^{A}	349.6
D	142.3^{a}	104.1	$537.2^{c,A}$	173.5	453.3^{d}	153.6

[a,b,c,d]Means within the same column (between-group comparison) with different superscript letters differ ($P < .05$).

[A]For comparison over time (within-group comparison), means followed by the capital superscript letter are significantly different ($P < .05$) from those in the previous period.

[1]Group A, 85 g of dried colostrum powder (DC; DCW Concentrate™; Smarte International, Inc., Calgary, AB, Canada); group B, 3 kg of colostrum from a first colostrum pool; group C, 85 g of DC plus 3 kg of colostrum from a first colostrum pool; group D, 85 g of DC plus 1.5 kg of colostrum from a first colostrum pool. There were 15 calves per group. One calf in group A died between 24 h and 30 d after birth.

significantly between h 24 and d 30 after birth. Changes were not significant in the other two groups over the same period.

Colostrum IgG concentration was 96 g/kg; IgG content of DC was 113 mg/g of DC.

DISCUSSION

Only calves that were clinically vigorous and that showed no signs of asphyxia were recruited for the study because asphyxia may compromise Ig absorption from the intestine (5). Reduced absorption of Ig is plausible, because morphologically and biochemically verifiable changes in the intestinal mucosa were found (8, 9, 16) to have been caused by intestinal ischemia secondary to neonatal asphyxia. Asphyctic calves were excluded also because in various clinical studies (4, 5, 20) asphyxia has been shown to increase the susceptibility of calves to disease, such as pneumonia, diarrhea, and septicemia caused by *E. coli*. This increased susceptibility may be attributed to hypoxia-induced pulmonary and intestinal lesions, which can facilitate the establishment of infections (4, 20).

Because Ig absorption depends both on the time of feeding and the quantity of Ig in the colostrum (12, 17, 18, 19), all calves were given their first feeding at the same time after birth, and the quantity of colostrum or DC solution fed was adjusted according to metabolic BW. We assumed that, at 2 h after birth, not all calves would voluntarily drink the relatively large volume of fluid stipulated in the protocol. Therefore, all calves were fed with an esophageal tube. A uniform procedure was used because method of feeding (voluntary intake vs. forced feeding with a stomach tube) influences the absorption of Ig (21).

No difference was significant among the four groups for morbidity, mortality, or BW gain. This lack of difference is surprising, because the calves in group A (fed DC in whole milk) had significantly lower serum IgG concentrations 24 h after birth than did calves in the other groups. The group A calves had a mean IgG concentration of 254.5 mg/100 ml. This low concentration may be because the 85-g dose of DC specified on the label contained only 9.6 g of IgG. By contrast, the dose of 3 kg of the pooled colostrum used in this trial contained 288 g of IgG.

According to accepted criteria, the calves in group A were hypogammaglobulinemic and therefore highly susceptible to disease (7, 13), especially in the present experiment, in which the calves were raised under conditions of a large dairy and were subjected to very high pathogen challenges. Nevertheless, group A had low morbidity and mortality rates for calves raised under intensive conditions. We can only speculate why calves in group A did not have more severe diseases, particularly the severe systemic infections that are typical of hypogammaglobulinemic calves. Because weak and asphyctic calves were excluded from the study, some disease risk was removed. Despite low IgG serum concentrations, the administration of 85 g of DC may have led to an effective local protection in the intestine through unabsorbed Ig or Ig fragments. An important role in the protection of the calf from enteric disease has been attributed to Ig that are not absorbed and that act locally in the intestine (10, 11, 14).

The purpose of treatments for calves in groups C and D was to investigate the effect of DC in combination with colostrum. The administration of 85 g of DC in 3 kg of colostrum (group C) tended to raise the IgG concentration above that in the group fed 3 kg of colostrum alone (group B), although the difference was not significant. The use of an esophageal tube to administer IgG may explain why relatively large doses of Ig given to calves in groups B and C did not lead to IgG blood concentrations as high as those reported in the literature (7, 19, 21). Administration of colostrum with the tube leads to lower serum concentrations of Ig than does voluntary suckling by calves (21). Radiological surveys (21) have shown that, after tube administration, colostrum entered the rumen first. Therefore, Ig in colostrum reach the small intestine much later and are absorbed there to a lesser extent because of the rapidly declining ability of the intestine to absorb Ig.

CONCLUSIONS

The results of this study should be applied with caution under ordinary dairy conditions, because our experimental calves were selected carefully to ensure vigor and health and were subjected to intensive clinical observation.

During enrollment, approximately 30% of newborn bull calves were excluded from the study because they did not meet selection criteria. This selection probably contributed to lower morbidity and mortality rates of calves fed only DC 2 h after birth compared with those of calves that were raised on this farm at the same time but not under experimental conditions.

The results of this study suggest several practical consequences and recommendations. When no fresh or frozen colostrum is available from the dam or other donor cows, the administration of 85 g of DC can be beneficial. Because of the very low Ig concentrations attained in serum after administration of this product, its use should be restricted to emergencies in which colostrum is not available. Use of a higher dose in order to attain higher serum Ig concentrations may not be economically justifiable, depending on cost of the product. Feeding of a mixture of DC and colostrum can be considered when the available colostrum is of low quality or when insufficient quantities are available; the DC probably is more useful as an extender of natural colostrum than as a colostrum substitute.

ACKNOWLEDGMENTS

The authors thank Cornell Kasbergen for making calves and facilities available for this experiment. This work was supported partially by a grant from the Deutsche Forschungsgemeinschaft (German Research Foundation).

REFERENCES

1 Binder, A. 1982. Der Einfluß verschiedener Tränkeverfahren auf den Immunglobulingehalt des Blutserums neugeborener Kälber. D.V.M. Diss., Vet. School, Hanover, Germany.

2 Boyd, J. W. 1972. The relationship between serum immune globulin deficiency and disease in calves: a farm survey. Vet. Rec. 90:645.

3 Davidson, J. N., S. P. Yancey, S. G. Campbell, and R. G. Warner. 1981. Relationship between serum immunoglobulin values and incidence of respiratory disease in calves. J. Am. Vet. Assoc. 179:708.

4 Eigenmann, U.J.E., E. Grunert, and K. Luetgebrune. 1983. Die Asphyxie des Kalbes. Prakt. Tierarzt. 64: 603.

5 Eigenmann, U.J.E., W. Zaremba, K. Luetgebrune, and E. Grunert. 1983. Untersuchungen über die Kolostrumaufnahme und die Immunglobulinabsorption bei Kälbern mit und ohne Geburtsazidose. Berl. Muench. Tieraerztl. Wochenschr. 96:109.

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

7 Hancock, D. D. 1985. Assessing efficiency of passive immune transfer in dairy herds. J. Dairy Sci. 68:163.

8 Heidbrink, U. 1988. Zur Asphyxia neonatorum des Kalbes: Die primäre Ursache der dabei auftretenden Darmsymptomatik. D.V.M. Diss., Vet. School, Hanover, Germany.

9 Kaup, F.-J., W. Drommer, E. Grunert, W. Zaremba, M. Pickel, and G. Harisch. 1988. Ultrastructural alterations of the intestinal barrier in newborn calves with experimentally induced local ischemia. Page 349 *in* Proc. 15th World Congr. Dis. Cattle, 1988. Vol. 1, World Assoc. Buiatrics, León, Spain.

10 Logan, E. F., and W. J. Penhale. 1971. Studies on the immunity of the calf to colibacillosis. III. The local protective activity of colostrum within the gastrointestinal tract. Vet. Rec. 89:628.

11 Logan, E. F., A. Stenhouse, D. J. Ormrod, and W. J. Penhale. 1974. The role of colostral immunoglobulins in intestinal immunity to enteric colibacillosis in the calf. Res. Vet. Sci. 17:290.

12 Matte, J. J., C. L. Girard, J. R. Seoane, and G. J. Brisson. 1982. Absorption of colostral immunoglobulin G in the newborn dairy calf. J. Dairy Sci. 65:1765.

13 McGuire, T. C., N. E. Pfeiffer, J. M. Weickel, and R. C. Bartsch. 1976. Failure of colostral immunoglobulin transfer in calves dying from infectious disease. J. Am. Vet. Assoc. 169:713.

14 Murakami, T., N. Hirano, A. Inoue, K. Chitose, K. Tsuchiya, K. Ono, Y. Naito, and T. Yanagihara. 1986. Protective effect of orally administered immunoglobulins against experimental calf diarrhea. Jpn. J. Vet. Sci. 48:237.

15 Naylor, J. M., D. S. Kronfeld, S. Bech-Nielsen, and R. C. Bartholomew. 1977. Plasma total protein measurement for prediction of disease and mortality in calves. J. Am. Vet. Assoc. 171:635.

16 Stockhofe, N. 1987. Zur Morphologie des jejunalen Enterozyten beim neugeborenen gesunden und asphyktischen Kalb-Semi-und Ultradünnschnitt-sowie Gefrierbruchtechnik. D.V.M. Diss., Vet. School, Hanover, Germany.

17 Stott, G. H., D. B. Marx, B. E. Menefee, and G. T. Nightengale. 1979. Colostral immunoglobulin transfer in calves. 1. Period of absorption. J. Dairy Sci. 62: 1632.

18 Stott, G. H., D. B. Marx, B. E. Menefee, and G. T. Nightengale. 1979. Colostral immunoglobulin transfer in calves. 2. The rate of absorption. J. Dairy Sci. 62: 1766.

19 Stott, G. H., D. B. Marx, B. E. Menefee, and G. T. Nightengale. 1979. Colostral immunoglobulin transfer in calves. 3. Amount of absorption. J. Dairy Sci. 62: 1902.

20 Zaremba, W., and E. Grunert. 1986. Zur Asphyxie des Kalbes. Prakt. Tieraerzt. 67, Coll. Vet. XVI (1985):17.

21 Zaremba, W., E. Grunert, W. Heuwieser, and H. Schiffner-Mehrens. 1985. Untersuchungen über die Immunglobulinabsorption bei Kälbern nach Verabreichung von Kolostrum per Schlundsonde im Vergleich zur freiwilligen Aufnahme. Dtsch. Tieraerztl. Wochenschr. 92:18.