Use of Glycerol as a Corn Replacement in Calf Starter Diets

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Summary Report 07/06/10

Project Number: 9-244 and 9-245

Title: Use of Glycerol as a replacement for corn in starter diets for individually fed dairy calves up to 9 weeks of age and in grain mixes during group feeding from 9 to 25 weeks of age.

Location(s): University of Minnesota, Calf and Heifer Research Facility, Southern Research and Outreach Center (SROC), Waseca, MN.

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Background & Justification: Glycerol is a sugar alcohol by-product of bio-diesel production. About 1 gallon of glycerin is produced for every 10 gallons of bio-diesel of which the glycerol content may vary between 63 and almost 100%. There is some uncertainty of the exact energy value of glycerol as an ingredient for animal feed but it has been successfully used as a replacement for corn up to 10% of the diet dry matter for lactating dairy cows. There is a lack of information on incorporating glycerol into diets for pre- and post weaned dairy heifer calves which has the potential to expand the market for this by product. Preliminary work at SROC indicates that there are no palatability problems using glycerol up to 6% of the mix in post weaning pellets for group fed dairy heifers.

Objectives: To evaluate the use of glycerol as a replacement for corn in diets on performance and health of dairy calves individually fed from 2 days up to 9 weeks of age and group fed from 9 to 25 week of age.

Study Overview

Animals and Methods

Phase 1 to 56 day study:- One hundred-twenty calves housed in individual pens from 3 commercial dairy farms were assigned to one of four 18% crude protein (CP) calf starters (25 calves/treatment) upon arrival at SROC at 2-4 days of age. Isocaloric and isonitrogenous starter diets included: 1), Complete texturized control; 2), Complete pellet control; 3), Complete pellet with 3% glycerol replacing corn; 4), Complete pellet with 6% glycerol replacing corn. All diets were full fed with access to fresh water. All calves were fed a 20% protein:20% fat medicated milk replacer at 0.625 lbs in 4.4 lbs of water twice daily for 35 days and once daily from day 36 to weaning at 42 days. Calves continued to be full-fed their respective diets post weaning from day 43 to the end of the study at 56 days. Bodyweights were taken

initially and on days 14, 28, 42, and 56. Hip heights will be taken initially and at day 56. Daily feed intake and health records were documented for each calf.

Phase 2 – 112 day study:- 105 calves from phase 1 were re-assigned to one of three grain mixes. Calves were fed the control 18% CP starter from phase 1 for 7 days after moving calves from individual to group pens of 7 calves/pen. Calves were then be transitioned to one of 3 corn/pellet grain mixes with 5 replicated group pens/treatment. Treatments included: 1), 16% CP corn and pellet grain mix control fed at 6 lbs/day for 84 days with free choice hay; 2), 16% CP corn and pellet grain mix with 3% glycerol fed as for treatment 1 for 56 days then 5 lbs/day from day 57 to 84; 3), 16% CP corn and pellet grain mix with 6% glycerol fed as for treatment 2. From days 85-112 all group pens will be fed a common diet of a 16% CP grain mix fed at 5 lbs/day with free choice hay. Bodyweights were taken initially and on days 28, 56, 84 and 112. Hip heights were taken initially, days 84 and 112. Daily feed intake and health records were documented for each group pen.

Statistical analyses: Data were analyzed using the PROC MIXED procedure of SAS and repeated measures analyses applied where appropriate. Contrasts were used to differentiate treatment combination effects.

Results and Discussion

Phase 1 nursery phase - The nutrient composition of the diets fed during the nursery phase are summarized in Table 1. The complete pellet consisted of the same ingredient composition to the complete texturized starter. The quality of pellet was very good and the addition of 3 or 6% glycerin maintained the quality. The crude protein content of the respective starters were within the specifications expected. Performance of calves are summarized in Tables 2 and 3 with health data summarized in Table 4.

There were no treatment differences in pre- and post weaning growth during the nursery phase. Optimal performance goals during the nursery phase are for calves to double their initial body weight with a frame growth of 4 inches by 2 months of age. Calves averaged 1.84 times their initial body weight with 3.85 inches of frame growth (Table 2). There were no treatment differences in calf starter and total dry matter intake although there was a numerical trend towards lower intakes in calves fed the pellet with 6% glycerin (Table 3). Pre- and post weaning feed efficiencies were not affected by treatment and were very similar to previous studies. There were no treatment differences in pre- and post weaning fecal scores or pre-weaning scouring days. Post weaning scouring days tended to be higher for calves fed the texturized calf starter vs. those fed the pellet diets. Pre-weaning and overall treatment costs/calf were highest for calves fed the pellet with 6% glycerin.

Conclusions for the nursery phase – Under the conditions of this study formulating a calf starter pellet with the same nutrient specifications of a texturized calf starter was very successful. Partially replacing corn with 3 or 6% glycerin in a calf starter pellet was acceptable. There were indications that 6% glycerin may affect health costs.

Phase 2 group feeding phase - Post weaning calf performance in group pens are summarized in Table 5, 6 and 7. Mixing 3 or 6% glycerin in a grain mix worked well for the 84 day period when treatments were applied. There were no treatment differences in calf growth within each of the 28 day weigh periods (Table 5). Body weight gain overall for the 112 days study was also similar across all calf groups. As expected grain intake was similar across calf groups during the 84 day treatment period and

overall, days 1 to 112 (Table 6). Numerically hay intake tended to be lower for calves fed the glycerin diets. This was reflected in overall hay and total dry matter intake which was higher for the control calf groups vs. those fed the glycerin diets which were not different. However, feed efficiencies were not affected by glycerin treatments days 1 to 84 or when all calves were fed a common diet form days 85 to 112. There were no treatment differences in changes in body condition score or hip height gain (Table 7).

Conclusions for the group feeding phase – Under the conditions of this study partially replacing corn in grain mixes with 3 or 6% glycerin did not affect calf performance when fed in group pens with free choice hay from 9 to 25 weeks of age,

Study conclusions overall - Glycerol can be used as an alternative energy source as a partial replacement for corn in starter diets at 3 or 6% of the total formulation for individually fed dairy calves up to 9 weeks of age and similarly in grain mixes during group feeding from 9 to 25 weeks of age .The current study confirmed a previous study with post weaned heifer calves in group pens which indicated up to 6% glycerin can effectively replace corn in grain mixes. Contrary to the current study, the previous study found that heifer calves fed a 16% crude protein grain mix pellet containing 6% glycerin for 84 days had improved daily gain compared to heifers fed pellets with no or 3% glycerin. Heifers fed the grain mix pellet containing 3 or 6% glycerin for 84 days with free choice hay also had improved feed efficiency compared to heifers fed pellets without glycerin included. These differences were not maintained when all heifers were fed a common whole corn and pellet mix from days 85 to 112. However, daily gains and feed intake during the current study tended to be better than in the previous study.

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Table 1. Nutrient composition of milk replacer and calf starters (CS)[1]

Item	Milk replacer	CS1	CS2	CS3	CS4
DM, %	98.36	87.79	89.02	88.43	88.51
CP, %	19.94	21.18	20.70	22.12	21.30
Fat, %	19.81	3.58	1.52	2.34	2.31
NDF, %	----	13.88	17.72	16.00	15.93
ADF, %	----	6.09	9.25	8.80	9.45
Ash, %	9.25	6.32	7.50	7.48	7.66
Ca, %	0.89	1.18	1.25	1.23	1.15
P, %	0.82	0.59	0.57	0.57	0.58
K, %	2.62	1.36	1.24	1.25	1.15
Mg, %	0.16	0.31	0.32	0.31	0.32
Na, %	1.13	0.22	0.25	0.31	0.38
Cu, ppm	13.4	30.2	27.8	17.0	21.9
Fe, ppm	24.4	138.2	235.4	237.2	263.5
Mn, ppm	31.0	104.0	105.5	79.8	93.7
Zn, ppm	29.6	137.7	137.9	96.8	117.8

[1] CS1 = complete texturized; CS2 = complete pellet; CS3 = complete pellet with 3% glycerin; CS4 = complete pellet with 6% glycerin.

Table 2 . Growth parameters day 1 to 56 of study.

	Treatments[1]					Contrasts		
	Control	**2**	**3**	**4**	**SEM**	**1 vs 2, 3, 4**	**2 vs. 3, 4**	**1 vs 3, 4**
No calves	30	30	30	30				
BW, lb								
Initial[2]	88.5	88.6	88.7	88.5	1.7			
d 14	96.5	96.6	95.9	96.1	0.63			
d 28	114.6	114.7	113.7	113.6	0.95			
d 42	134.5	135.1	135.7	133.2	1.36			
d 56	164.0	164.1	163.3	160.5	1.93			
Total BW gain, lb								
d 1 to d 42	46.1	46.4	47.4	44.5	1.35	0.99	0.76	0.93
d 1 to d 56	**75.6**	**75.6**	**75.0**	**72.2**	**1.68**	**0.50**	**0.35**	**0.34**
ADG, lb/d								
d 1 to 14	0.55	0.55	0.51	0.54	0.05			
d 15 to 28	1.31	1.30	1.29	1.25	0.05			
d 29 to 42	1.43	1.47	1.59	1.40	0.06			
d 1 to 42	1.10	1.10	1.13	1.06	0.03	0.99	0.76	0.93
d 43 to 56	2.12	2.08	1.98	1.95	0.07			
d 1 to 56	**1.35**	**1.35**	**1.34**	**1.29**	**0.03**	**0.50**	**0.35**	**0.34**
HH, inches								
Initial[3]	31.5	31.6	31.6	31.7	0.17			
d 56	35.5	35.5	35.4	35.2	0.13	0.46	0.26	0.28
HH gain, inches								
d 1 to 56	**3.94**	**3.94**	**3.87**	**3.67**	**0.13**	**0.46**	**0.26**	**0.28**

[1]Treatments:

[2]Initial body weight (BW) utilized as a covariate for body weight, ADG and intake data when significant.

[3]Initial hip height (HH) utilized as a covariate for hip height (d 56) and hh gain.

[a,b]Means within a row without common superscripts are different at $P < 0.05$.

Table 3. Milk replacer, starter and total DM intake and feed efficiency.

	Treatments					Contrasts		
	Control	**2**	**3**	**4**	**SEM**	**1 vs 2, 3, 4**	**2 vs. 3, 4**	**1 vs 3, 4**
Milk Replacer	**----------% DM basis--------**							
Intake, lb/d								
d 1 to 14	1.21	1.23	1.22	1.22	0.004			
d 15 to 28	1.24	1.24	1.24	1.24	0.004			
d 29 to 42	0.92	0.92	0.92	0.92	0.004			
d 1 to 42	1.12	1.13	1.13	1.13	0.002	0.12	0.48	0.22
Total MR intake, lb								
d 1 to 42	**47.2**	**47.4**	**47.3**	**47.3**	**0.1**	**0.12**	**0.48**	**0.22**
Starter intake, by period, lb/d								
d 1 to 14	0.11	0.10	0.10	0.08	0.02			
d 15 to 28	0.71	0.67	0.71	0.63	0.06			
d 29 to 42	1.64	1.69	1.82	1.51	0.09			
d 43 to 56	4.23	4.19	4.16	3.91	0.12			
Total Starter intake, lb								
d 1 to d 42[1]	34.5	34.5	37.3	31.0	1.86	0.91	0.89	0.88
d 1 to d 56	93.5	93.2	95.2	85.7	3.64	0.62	0.54	0.50
Total DM intake by period, lb/d								
d 1 to 14	1.32	1.33	1.33	1.30	0.02			
d 15 to 28	1.94	1.91	1.95	1.86	0.06			
d 29 to 42	2.56	2.61	2.74	2.43	0.09			
d 43 to 56	4.24	4.26	4.16	3.92	0.12			
Total DM intake, lb								
d 1 to d 42[2]	81.7	81.9	84.6	78.3	1.87	0.96	0.86	0.92
d 1 to d 56	140.8	140.8	142.8	133.2	3.52	0.72	0.64	0.63
Feed per Gain								
d 1 to 42	1.79	1.78	1.80	1.77	0.03	0.79	0.83	0.86
d 43 to 56	2.11	2.07	2.17	204	0.07	0.86	0.65	0.99
d 1 to 56	1.88	1.87	1.92	1.86	0.03	0.99	0.69	0.89

[1]Treatment P = 0.13
[2]Treatment P = 0.12

Table 4. Serum protein and health data

	Treatments					Contrasts		
	Control	**2**	**3**	**4**	**SEM**	**1 vs 2, 3, 4**	**2 vs. 3, 4**	**1 vs 3, 4**
Serum Protein	5.40	5.47	5.31	5.44	0.10	0.96	0.43	
Fecal Score[1]								
Period								
d 1 to 14	1.64	1.51	1.49	1.55	0.06			
d 15 to 28	1.32	1.32	1.27	1.36	0.04			
d 29 to 42	1.13	1.16	1.15	1.14	0.03			
d 43 to 56	1.23	1.15	1.17	1.27	0.04			
d 1 to 42	1.35	1.31	1.30	1.34	0.02	0.28	0.81	0.35
d 1 to 56	1.33	1.28	1.27	1.33	0.02	0.21	0.60	0.31
Scouring days[2]								
# Days ≥ 3								
1 to 42[3]	2.10	1 .39	1.65	2.32	0.30	0.37	0.11	0.75
43 to 56	0.28	0.05	0.14	0.18	0.08	**0.08**	0.23	0.22
# Days = 4								
1 to 42	0.00	0.03	0.00	0.001	0.02	0.61	0.13	0.97
Treatment cost, $								
1 to 42	0.52[a]	0.44[a]	0.30[a]	1.21[b]	0.21	0.57	0.21	0.34
43 to 56[3]	0.10	0.00	0.00	0.42	0.17	0.99	0.21	0.67
1 to 56	0.61[a]	0.37[a]	0.24[a]	1.64[b]	0.26	0.65	**0.07**	0.30

[1]Fecal score = 1 to 4; 1 = normal, ≥ 3 = scours

[2]Scouring day = any day with a fecal score≥ 3.

[3]Treatment P = 0.13

[a,b]Means within a row without common superscripts are different at $P < 0.05$.

Table 5 . Growth parameters d 1 to 112 of grower period.

	Treatments[1]				Contrasts	
	Control	2	3	SEM	1 vs. 2, 3	2 vs. 3
No. pens (7 hfrs/pen)	5	5	5			
BW[2] , lb						
Initial	185.8	186.6	186.7	1.55		
d 28	247.1	248.7	248.8	1.85		
d 56	310.7	314.2	315.6	1.77		
d 84	375.8	374.7	378.4	2.23		
d 112	443.2	440.8	442.2	2.93		
d 1 to 112	344.2	344.6	346.3	1.88	0.59	0.52
ADG[2], lb/d						
d 1 to 28	2.18	2.22	2.22	0.07		
d 29 to 56	2.27	2.34	2.38	0.07		
d 57 to 84	2.33	2.15	2.24	0.07		
d 85 to 112	2.41	2.36	2.29	0.07		
d 1 to 112	2.30	2.27	2.28	0.03	0.32	0.58
BWG[2], lb						
d 1 to 28	61.0	62.2	62.2	1.96		
d 29 to 56	63.6	65.5	66.6	1.96		
d 57 to 84	65.2	60.2	62.7	1.96		
d 85 to 112	67.5	66.1	64.1	1.96		
Total gain, lb						
d 1 to 112	257.6	254.2	255.4	3.36		

[1]Treatments

[2]Initial body weight (BW) during the starter period (study 8-242) utilized as a covariate for body weight and ADG when significant.

[a,b]Means within a row without common superscripts are different at $P < 0.05$.

Table 6. Grain and hay intake day 1 to 112 of grower period.

	Treatments[1]				Contrasts	
	Control	2	3	SEM	1 vs. 2, 3	2 vs. 3
No. pens (7 hfrs/pen)	5	5	5			
Grain Intake, lb/d	----------% DM basis----------					
d 1 to 28	5.28	5.32	5.35	0.02		
d 29 to 56	5.35	5.32	5.34	0.02		
d 57 to 84	4.50	4.47	4.47	0.02		
d 84 to 112	4.49	4.49	4.45	0.02		
d 1 to 112	4.90	4.90	4.90	0.01	0.86	0.87
Hay Intake, lb/d						
d 1 to 28	1.39	1.38	1.27	0.06		
d 29 to 56	4.39	4.12	4.10	0.13		
d 57 to 84	6.87	6.54	6.50	0.12		
d 84 to 112	8.48	8.34	8.08	0.12		
d 1 to 112	5.28	5.10	4.99	0.08	**0.02**	0.32
Total Intake, lb/d						
d 1 to 28	6.67	6.70	6.61	0.07		
d 29 to 56	9.75	9.44	9.44	0.14		
d 57 to 84	11.4	11.0	11.0	0.12		
d 84 to 112	13.0	12.8	12.5	0.13		
d 1 to 112	10.2	10.0	9.89	0.08	**0.02**	0.37
Feed to Gain, DM/lb						
d 1 to 28	3.08	3.02	2.99	0.08		
d 29 to 56	4.30	4.06	3.96	0.12		
d 57 to 84	4.91	5.11	4.91	0.14		
d 84 to 112	5.41	5.45	5.49	0.13		
d 1 to 112	4.43	4.41	4.34	0.05	0.38	0.28

[a,b]Means within a row without common superscripts are different at $P < 0.05$.

Table 7 . Body condition score and hip height day 1 to 112 of grower period.

	Treatments				Contrasts	
	Control	2	3	SEM	1 vs. 2, 3	2 vs. 3
No. pens (7 hfrs/pen)	5	5	5			
BCS						
Initial	2.98	3.00	2.98	0.03		
d 56	3.44	3.41	3.36	0.07		
d 112	3.76	3.84	3.77	0.04		
d 1 to 112	3.60	3.62	3.57	0.05	0.83	0.57
BCS Change						
d 1 to 112	0.78	0.84	0.79	0.04	0.53	0.47
HH, inches[1]						
d 1	36.3	36.5	36.4	0.13		
d 56	40.8	41.1	41.3	0.21		
d 112	44.3	44.4	44.4	0.16		
1 to 112	40.5	40.7	40.7	0.12	0.16	0.98
HH gain[1], in.						
d 1 to 112	7.93	7.98	8.00	0.16	0.79	0.95

[1]Initial hip height during the starter period (study 8-242) utilized as a covariate.

[a,b]Means within a row without common superscripts are different at $P < 0.05$.