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INFLUENCE OF FLOCCULENT COATING ON THE FEEDING VALUE OF COTTONSEED MEAL AND STEAM-FLAKED CORN FOR FEEDLOT CATTLE

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ABSTRACT: Ninety-six crossbred steers (200 kg) were used to evaluate the influence of coating cottonseed meal (CSM) with a flocculent (Polyfloc CE239, Betz Dearborn Inc., Trevose, PA) on its feeding value. Treatments consisted of a 78% concentrate growing diet supplemented with 8% CSM or 5% fishmeal (FM). Three levels of flocculent addition were evaluated (0, .68 or 6.8 g/kg CSM). Before mixing with CSM, the flocculent was diluted in water (0, 2.12 and 212 g/L). An equivalent amount of water was also added to FM so that all diet had equal moisture content. Flocculent did not influence (P > .10) ADG, feed efficiency, or dietary NE. Feed efficiency and dietary NE were greater (P < .10; 6 and 5%, respectively) for FM then for CSM. Four crossbred steers (236 kg) with ruminal and duodenal cannulas were used in a 4×4 Latin square design to evaluate treatment effects on digestive function. Ruminal and total tract digestion of OM and starch were not affect (P > .10) by treatments. Although, high-level flocculent depressed postruminal starch digestion (4%, P < .10). Flocculent increased (22%, P < .05) ruminal degradation of feed N. Ruminal degradation of feed N was lower (13%, P < .05) for FM than for CSM. Eighty-four crossbred steers (317 kg) were used to evaluate the influence of flocculent coating of SFC (0 versus 1.1g/kg) on growth performance of steers were fed a 70% SFC-based diet. Flocculent did not influence (P > .10) growth performance or the NE value of the diet. Eight crossbred steers (329 kg) with ruminal and duodenal cannulas were used in a crossover design to evaluate treatment effects on digestive function. Flocculent coating of SFC did not affect (P > .10) ruminal and total tract digestion of the OM, NDF, starch, and N. However, as with CSM, flocculent decreased (P < .05) postruminal and total tract starch digestion (6 and 2%, respectively). Flocculent did not influence (P > .10) ruminal pH or VFA molar proportions. We conclude that flocculent coating of high-protein and high-starch feedstuffs will not have a detrimental effect on growth performance and digestive function.

Key Words: Flocculent, Cattle Performance, Digestion

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Introduction

Increasingly stringent environmental regulations have prompted processing plants to incorporate coagulants (ie. alum, organic polyamines) and/or flocculents to further assist in the clarification of waste streams. The influence that these precipitating agents might have on the feeding value of these byproduct for feedlot cattle has not been evaluated. The objective of this study was to evaluate the influence of flocculent coating on the feeding value of high protein (cottonseed meal) and high-starch (steam-flaked corn) feed ingredients.

Experimental Procedure

Trial 1. Ninety-six crossbred steers (200 kg, initially) were blocked by weight and randomly assigned within weight group to 16 pens (six steers per pen). Pens were 43 m^2 with 22 m^2 overhead shade. The trial was initiated June 17, 1997. Average daily minimum and maximum air temperature during the trial was 22.8 and 39.6EC, respectively. There was .8 cm precipitation, and average daily relative humidity was 45.3%. Treatment were: 1) 8% cottonseed meal (**CSM**); 2) 8% CSM coated with .68 g/kg flocculent (Polyfloc CE239, Betz Dearborn Inc., Trevose, PA); 3) 8% CSM coated with 6.8 g/kg flocculent and 4) 5% fishmeal and 3% tapioca. Before mixing with CSM the flocculent was diluted in water (0, 2.12 and 212 g/L). An equivalent amount of water was also added to the fishmeal so that all diet had equal moisture content. The fishmeal treatment was included as a positive control. Based on formulation, the basal diet was expected (NRC, 1996, Level 1) to be deficient in metabolizable lysine. Thus, we expect enhanced feed/gain with the fishmeal treatment. Composition of experimental diets is shown in Table 1. Diets were prepared at approximately weekly intervals and stored in plywood boxes located in front of each pen. Steers had ad libitum access to their diet. Fresh feed was added twice daily. Upon initiation of the study steers were implanted with Synovex-S® (Fort Dodge Animal Health, Fort Dodge, IA). Energy gain (EG) was calculated by the equation: $EG = ADG^{1.095}\ .0557W^{.75}$, where EG is the daily energy deposited (Mcal/d), W is the mean shrunk body weight (kg; NRC, 1984). Maintenance energy (EM) was calculated by the equation: $EM = .O77W^{.75}$ (Lofgreen and Garrett, 1968). The NE_m and NE_g value of the diets were obtained by means of the quadratic equation ($x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2c}$) where a = -.41EM, b = .877EM + .41DMI + EG, c = -.877DMI, and $NE_g = .877NE_m - .41$. For calculating steer performance, initial and final full weights were reduced 4% to account for digestive tract fill. Pens were used as experimental units. The trial was analyzed as a randomized complete block design (Hicks, 1973). Treatment effects were tested for the following contrasts: fishmeal vs CSM; normal vs treated CSM; .68 vs 6.8 g flocculent/kg CSM.

Trial 2. Four crossbred steers (236 kg) with cannulas in the rumen and proximal duodenum (Zinn and Plascencia, 1993) were used in a replicated 4×4 Latin square experiment to study treatment effects on characteristics of digestion. Treatments were the same as those used in Trial 1 (Table 1), with .40% chromic oxide added as a digesta marker. Steers were maintained in individual pens with access to water at all times. Diets were fed at 0800 and 2000 daily. Dry matter intake was restricted to 2% of body weight. Experimental periods were 2 wk, with 10 d for diet adjustment and 4 d for collection. During collection, duodenal and fecal samples were taken twice daily as follows: d 1, 0750 and 1350; d 2, 0900 and 1500; d 3, 1050 and 1650, and d 4, 1200 and 1800. Upon completion of the trial, approximately 500 mL of ruminal fluid were obtained from each steer, composited across diets; bacteria were isolated via differential centrifugation (Bergen et al., 1968). The microbial isolates were prepared for analysis by oven drying at 70°C and grinding with mortar and pestle. Feed, duodenal and fecal samples were prepared for analysis by oven drying at 70°C and grinding in a lab mill (Micro-Mill, Bel-Arts Products, Pequannock, NJ). Samples were oven dried at 105°C until no further weight was lost and stored in tightly sealed glass jars. Samples were subjected to all or part of the following analysis: ash, ammonia N, Kjeldahl N (AOAC, 1984); chromic oxide (Hill and Anderson, 1958); purines (Zinn and Owens, 1986); and starch (Zinn, 1990). Microbial organic matter (MOM) and N (MN) leaving the abomasum were calculated using purines as a microbial marker (Zinn and Owens, 1986). Organic matter fermented in the rumen was considered equal to OM intake minus the difference between the amount of total OM reaching the duodenum and MOM reaching the duodenum. Feed N escape to the small intestine was considered equal to total N leaving the abomasum minus ammonia-N and MN and, thus, includes any endogenous additions. This trial was analyzed as a 4×4 Latin square (Hicks, 1973). Treatment contrasts were tested as in Trial 1.

Trial 3. Eighty-four crossbred steers (317 kg, initially) were randomly assigned to 14 pens (43 m^2 with 22 m^2 overhead shade). The trial was initiated September 17, 1997. Average daily minimum and maximum air temperature during the trial was 15.7 and 31.7EC, respectively. There was 2.2 cm precipitation, and average daily relative humidity was 48.7%. Treatments consisted of 0 vs 1.1 g flocculent/kg steam-flaked corn (**SFC**). Before mixing with SFC the flocculent was diluted in water (212 g/L). An equivalent amount of water was also added to the control diet so that all diets had equal moisture content. Composition of experimental diets is shown in Table 5. The protocol for this trial was similar to Trial 1.

Trial 4. Eight crossbred steers (329 kg) with cannulas in the rumen and proximal duodenum were used in a crossover design study treatment effects on characteristics of digestion. Treatments were the same as those used in Trial 3 (Table 5), with .40% chromic oxide added as a digesta marker. The protocol for this trial was similar to Trial 2.

Results and Discussion

The influence of flocculent coating of CSM on growth performance is shown in Table 2. Flocculent did not influence (P > .10) ADG, feed efficiency, or dietary NE. Feed efficiency and dietary NE were greater (P < .10; 6 and 5%, respectively) for FM then for CSM. This improvement in feed/gain was expected because of the variance in metabolizable amino acid supply versus requirements (NRC, 1996).

The influence of flocculent coating of CSM on digestion is shown in Tables 3 and 4. Ruminal and total tract digestion of OM and starch were not affect (P > .10) by treatments. Although, high-level flocculent tended to depress postruminal starch digestion (4%, P < .10). Flocculent increased (22%, P < .05) ruminal degradation of feed N. As expected (NRC, 1985, 1996), ruminal degradation of feed N was lower (13%, P < .05) for FM than for CSM. There were no treatment effects on ruminal pH or VFA molar proportions.

The influence of flocculent coating of SFC on growth performance is shown in Table 6. As in Trial 1, flocculent did not influence (P > .10) growth performance or the NE value of the diet.

The influence of flocculent coating of SFC on digestion is shown in Tables 7 and 8. Flocculent coating of SFC did not affect (P > .10) ruminal and total tract digestion of the OM, NDF, starch, and N. However, as with CSM, flocculent decreased (P < .05) postruminal and total tract starch digestion (6 and 2%, respectively). As in Trial 1, flocculent did not influence (P > .10) ruminal pH or VFA molar proportions.

Implications

We conclude that flocculent coating of high-protein and high-starch feedstuffs will not have a detrimental effect on growth performance and digestive function. High levels of flocculent coating may enhance ruminal degradation of associated protein.

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Table 1. Composition of experimental diets fed to steers (Trials 3 and 4)[a]

	Cottonseed meal			
	Flocculent level, g/kg cottonseed meal[b]			
Item	0	1	10	Fish meal
Ingredient composition, % (DM basis)				
Sudangrass hay	22.00	22.00	22.00	22.00
Steam-flaked corn	55.05	55.05		55.05
Yellow grease	4.00	4.00	55.05	4.00
Molasses cane	8.00	8.00	4.00	8.00
Cottonseed meal	8.00	8.00	8.00	
Fishmeal			8.00	5.00
Tapioca				3.00
Flocculent, g/kg cottonseed meal	.80	.68	6.8	.80
Urea	1.50	.80	.80	1.50
Limestone	.15	1.50	1.50	.15
Magnesium oxide	.50	.15	.15	.50
TM salt[c]		.50	.50	
Nutrient composition (DM basis)[d]				
NE, Mcal/kg				
Maintenance	2.09	2.09	2.09	2.09
Gain	1.43	1.43	1.43	1.44
Crude protein, %	13.4	13.4	13.4	13.2
UIP, %	5.1	5.1	5.1	5.6
Calcium, %	.75	.75	.75	1.06
Magnesium, %	.34	.34	.34	.30
Phosphorus, %	.34	.34	.34	.41

[a]Chromic oxide (.40%) was added as a digesta marker in Trial 1.

[b]Flocculent (BetzDearborn Polyfloc CE239) was diluted with water (21.5 g/L, and then mixed onto steam-flaked corn at the rate of 1.1g flocculent/kg corn.

[c]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, 1.24%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 92.96%.

[d]Based on tabular values for individual feed ingredients (NRC, 1996).

Table 2. Influence of flocculent coating of cottonseed meal on feedlot cattle growth performance and NE value of the diet (Trial 1).

	Cottonseed meal				
	Flocculent level, g/kg			Fish	
Item	0	.68	6.8	meal	SEM
Pens	4	4	4	4	
BW, kg[a]					
Initial	217	221	222	219	2
Final	297	300	303	302	2
ADG, kg	1.43	1.40	1.46	1.49	.03
DMI, kg[b]	6.75	6.87	7.01	6.70	.09
F/G[bc]	4.71	4.89	4.83	4.50	.12
Dietary NE, Mcal/kg					
NEm[b]	1.92	1.88	1.90	1.99	.03
NEg[b]	1.27	1.24	1.26	1.34	.03

[a]Initial and final weights were reduced by 4% to account for digestive tract fill
[b]Fishmeal vs cottonseed meal, $P < .10$.
[c]Feed efficiency: DM intake/gain

Table 3. Influence of flocculent coating of cottonseed meal on ruminal pH, VFA molar proportions, and estimated methane production (Trial 2).

	Cottonseed meal				
	Flocculent level, g/kg			Fish	
Item	0	.68	6.8	meal	SEM
Steer	4	4	4	4	
Ruminal pH	6.51	6.55	6.54	6.68	.07
Ruminal VFA, mol/100 mol					
Acetate	59.0	56.2	59.7	58.9	2.1
Propionate	31.7	32.8	29.7	30.7	2.2
Butyrate	9.4	11.0	10.7	10.4	.3

Table 3. Influence of flocculent coating of cottonseed meal on characteristics of ruminal and total tract digestion (Trial 2).

	Cottonseed meal				
	Flocculent level,			Fish	
Item	0	.68	6.8	meal	SEM
Steer	4	4	4	4	
Ruminal digestion, %					
OM	56.8	61.3	60.6	58.0	1.9
NDF	43.4	47.9	49.7	52.4	3.5
Starch	78.6	78.8	78.6	79.5	1.8
Feed N[ab]	60.9	70.3	65.0	56.7	2.5
MN_{eff}[ac]	26.5	26.3	26.5	23.1	2.2
N_{eff}[ad]	1.1	1.0	1.1	1.2	3.3
Total tract digestion,					
OM	76.7	78.1	77.0	75.8	.8
NDF	47.5	49.5	48.9	49.5	1.1
Starch	98.5	98.7	98.0	98.3	.3
N	67.5	68.9	65.9	66.3	1.2

[a]Cottonseed meal vs fishmeal, $P < .05$.
[b]Flocculent effect (0 versus 1 and 10 g/kg cottonseed meal), $P < .05$.
[c]Microbial N efficiency: Microbial N, g/kg OM fermented.
[d]N efficiency: Nonammonia N entering the small intestine/N intake.

Table 5. Composition of experimental diets fed to steers (Trials 3 and 4)[a]

Item	Flocculent, mg/kg corn 0	1.1
Ingredient composition, % (DM basis)		
Sudangrass hay	10.00	10.00
Alfalfa hay	4.00	4.00
Steam-flaked corn	70.00	70.00
Yellow grease	3.50	3.50
Molasses cane	6.00	6.00
Cottonseed meal	3.00	3.00
Flocculent, g/kg corn[b]		1.1
Urea	1.00	1.00
Limestone	1.80	1.80
Magnesium oxide	.15	.15
Ammonium sulfate	.15	.15
Laidlomycin, mg/kg	11.5	11.5
Trace mineral salt[c]	.40	.40
Nutrient composition (DM basis)[d]		
NE, Mcal/kg		
Maintenance	2.21	2.21
Gain	1.53	1.53
Crude protein, %	12.6	12.6
UIP, %	4.0	4.0
Calcium, %	.75	.75
Magnesium, %	.30	.30
Phosphorus, %	.33	.33

[a]Chromic oxide (.40%) was added as a digesta marker in Trial 1.

[b]Flocculent (BetzDearborn Polyfloc CE239) was diluted with water (21.5 g/L, and then mixed onto steam-flaked corn at the rate of 1.1g flocculent/kg corn.

[c]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, 1.24%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 92.96%.

[d]Based on tabular values for individual feed ingredients (NRC, 1996).

Table 6. Influence of flocculent coating of steam-flaked corns on feedlot cattle growth performance and NE value of the diet (Trial 3).

Item	Flocculent, g/kg 0	1.1	SEM
Pen replicates	7	7	
Weight, kg[a]			
Initial	320	313	6
Final	410	402	5
ADG, kg	1.60	1.60	.04
DMI, kg/d	7.42	7.40	.06
Feed efficiency	4.71	4.65	.13
Dietary NE, Mcal/kg			
Maintenance	2.34	2.34	.03
Gain	1.64	1.64	.02
Observed/expected NE			
Maintenance	1.06	1.06	.01
Gain	1.07	1.07	.01

[a]Initial and final weights were reduced by 4% to account for digestive tract fill.

Table 7. Influence of flocculent coating of steam-flaked corn on characteristics of ruminal and total tract digestion of OM, NDF, starch, and N (Trial 4).

	Flocculent, g/kg corn		
Item	0	1.1	SEM
Steer replicates	8	8	
Ruminal digestion, %			
OM	56.8	55.3	1.3
NDF	33.2	30.0	3.2
Starch	78.2	76.8	1.2
Feed N	52.2	51.7	1.8
MN efficiency[a]	24.8	24.3	.8
N efficiency[b]	1.15	1.12	.01
Total tract digestion, %			
OM	78.1	77.5	.4
NDF	40.3	41.2	1.1
Starch[c]	98.1	96.4	.3
N	66.2	65.9	1.0

[a]Microbial N, g/kg OM fermented.
[b]Nonammonia N entering the small intestine/N intake
[c]Treatments differ, $P < .05$.

Table 8. Influence of flocculent coating of steam-flaked corn on ruminal pH, VFA molar proportions, and estimated methane production (Trial 2).

	Flocculent, g/kg corn		
Item	0	1.1	SEM
Steer replicates	8	8	
Ruminal pH	6.44	6.66	.07
Ruminal VFA, mol/100 mol			
Acetate	56.0	53.4	1.6
Propionate	35.2	38.3	2.0
Butyrate	8.8	8.4	.5