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CLAYTON LIVESTOCK RESEARCH CENTER

15 NMSU Lane Clayton, New Mexico 575-374-2566

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Substituting steam-flaked corn with 20% whole shelled corn in finishing diets containing 0, 15, or 30% wet distiller's grains plus solubles did not affect performance or feed conversion by feedlot heifers

M. R. McDaniel*, C. A. Löest*, D. A. Walker*, K. M. Taylor*, N. A. Elam†, and N. A. Cole‡

*Department of Animal and Range Sciences, New Mexico State University, Las Cruces, 88003; †Nutrition Services Associates, Hereford, TX; ‡USDA-ARS Conservation and Production Research Laboratory Renewable Energy and Manure Management Research Unit, Bushland, TX 79012

Introduction

Escalating energy prices are a contributing factor to the increasing costs of production in the cattle feeding industry. Rapid expansion of the ethanol industry has led to large supplies of co-product. These co-products provide feedlots with an attractive alternative to high-priced corn.

Steam-flaking corn utilizes physical and chemical processes to increase its feeding value. Starch gelatinization in the steam chest followed by rolling pressure of the flaking process increases starch availability and extent of ruminal fermentation. Unfortunately, these improvements do not come without cost. It is possible that grain processing costs could be partially alleviated if substituting steam-flaked corn with whole shelled corn in diets containing wet distiller's grains plus solubles comes without negative implications on feedlot performance. Also, the use of co-products reduces the amount of energy, labor, and mechanical wear required for daily feed mill production.

Previous research (Vander Pol et al., 2008; Corrigan et al., 2009) has demonstrated that there are interactions between grain processing method and inclusion amount of wet distiller's grains plus solubles in the diet. When wet distiller's grains are added to diets based on dry-rolled corn, feed conversion and animal performance improved. In contrast, the addition of wet distiller's grains to diets based on steam-flaked corn has either a negative impact or does not affect feed conversion and animal performance. The objectives of this study were to evaluate the effects of whole shelled corn substitution for steam-flaked corn in diets containing different amounts of wet distiller's grains on feedlot heifer performance, feed conversion, and carcass characteristics.

Experimental Procedures

Cattle. In June 2009, 718 Angus-cross heifers were purchased from sale barns in Kentucky and shipped to the Clayton Livestock Research Center. At initial processing, cattle were individually weighed using a single animal squeeze chute (Silencer, Moly Manufacturing, Inc.) suspended from two load cells. Cattle were uniquely identified with a numbered ear tag, vaccinated against clostridial and viral diseases (Ultrabac 7 and Pyramid 10; Pfizer Animal Health, Exton, PA and Fort Dodge Animal Health, Fort Dodge, IA), and treated with an external parasiticide (Noromectin; Norbrook, Inc., Lenexa, KS). Metaphylaxis included 10 mg of Micotil (Elanco Animal Health, Indianapolis, IN) per kilogram of body weight. Heifers were revaccinated and implanted with Revalor-IH (Intervet/Schering Plough Animal Health, Millsboro, DE) three weeks after initial processing. The heifers were utilized in a growing experiment prior to beginning the current finishing experiment. Heifers were weighed individually, and re-implanted with Revalor-200 (Intervet/Schering Plough Animal Health, Millsboro, DE) before initiating this finishing experiment. Individual weights were utilized for sorting the heifers into one of three weight blocks, and one of six dietary treatments (Table 1). Heifers that were identified as sick or outliers from the weight groups were not utilized in the experiment, resulting in a total of 642 heifers.

Experimental Design. Heifers were assigned to 36 soil-surfaced pens equipped with fenceline bunks and continuous flow water tanks in a randomized complete block design (3 blocks based on initial body weight). To eliminate possible carryover effects, heifers were evenly distributed across pens based on treatments from the previous growing experiment. Treatments

(Table 1) were arranged in a 2 by 3 factorial, and consisted of 6 finishing diets based on steam-flaked corn with 0 or 20% whole shelled corn replacing steam-flaked corn, and 0, 15, or 30% wet distiller's grains plus solubles replacing steam-flaked corn (dry basis). Within each weight block, dietary treatments were randomly assigned to 12 pens. Diets were formulated to contain approximately 8% rumen degradable protein, and were not isonitrogenous. Due to the high concentration of fat in wet distiller's grains plus solubles, tallow was used to decrease the variability in fat among dietary treatments. The whole shelled corn was conditioned, but not steam-flaked. The wet distiller's grains plus solubles consisted of a blend from corn grain with no more than 10% from sorghum grain, were procured from an ethanol plant in Hereford, TX, and transported as needed to the research center.

Management, Feeding, and Weighing Procedures. Daily estimates of the quantity of unconsumed feed remaining in the bunks were made for each pen at approximately 7:00 AM each morning. Bunks were managed to allow trace amounts of remaining feed before feeding each morning. Dietary treatments were mixed in an overhead mixer, and delivered to pens of cattle once daily. Weekly samples of feedstuffs and complete diets were obtained and analyzed for dry matter. Composited samples were analyzed by a commercial laboratory (Servi-Tech Laboratories, Amarillo, TX). Feed refusals were collected weekly, weighed, and a sample was analyzed for dry matter to calculate dry matter intake.

Pens of heifers were weighed using a pen scale on days 0, 56, and 108 of the study. After 108 days on feed, all heifers were shipped to a commercial abattoir in Amarillo, TX. Following a 24-hour chill, carcass data were collected by trained personnel from Cattlemen's Carcass Data Service (West Texas A & M University, Canyon, TX). The data collected included hot carcass weight, ribeye area, 12th rib backfat, kidney, pelvic, and heart fat, marbling score, USDA quality grade, and calculated USDA yield grade. Livers were evaluated for presence and severity of abscesses and were either not condemned or scored (A-, A, A+). Carcasses which were railed out with excessive trim were not used in analyzing hot carcass weight and dressing percent data.

Statistical Analysis. Performance and carcass data were analyzed as a randomized complete block design using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Treatments included a 2 by 3 factorial arrangement, and pen was the experimental unit.

Due to an abattoir error, 15% of the heifers were slaughtered before an antemortem inspection, which resulted in condemned carcasses. Therefore, only 542 carcasses were available for statistical analyses, and carcass-adjusted performance measures were not calculated. Carcass quality grades and liver abscesses were analyzed as binomial proportions using the GLIMMIX procedure of SAS. Health data were analyzed using the Freq and Chi-Square procedure of SAS and Fisher's exact test. Treatment differences were considered significant at $P \leq 0.05$.

Results

Interactions of Whole Shelled Corn and Wet Distiller's Grains Plus Solubles. A tendency for an interaction ($P = 0.08$) between whole shelled corn and wet distiller's grains plus solubles occurred for number of carcasses grading USDA Choice or better. The number of carcasses grading USDA Choice or better decreased with increasing concentrations of wet distiller's grains plus solubles in diets containing 0% whole shelled corn. In contrast, number of carcasses grading USDA Choice or better were lowest for 0%, highest for 15%, and intermediate for 30% wet distiller's grains plus solubles in diets containing 20% whole shelled corn. No other interactions ($P \geq 0.14$) between whole shelled corn and wet distiller's grains plus solubles occurred for dry matter intake, daily gain, feed conversion, and carcass characteristics.

Effects of Whole Shelled Corn. Heifers fed steam-flaked corn-based diets containing 20% versus 0% whole shelled corn had greater ($P < 0.01$) dry matter intake, but final body weight, average daily gain, and feed to gain ratio were not affected ($P \geq 0.11$; Table 2). Replacing 20% of the steam-flaked corn with whole shelled corn did not affect ($P \geq 0.16$) hot carcass weight, ribeye area, 12th rib backfat, kidney, pelvic, and heart fat, calculated USDA yield grade, marbling score, or liver abscesses. The percentage of carcasses grading USDA choice or better tended to be lower ($P = 0.07$), and the percentage of carcasses grading USDA select were higher ($P = 0.03$) for cattle fed steam-flaked corn-based diets with 20% versus 0% whole shelled corn. Morbidity and mortality of heifers were not affected ($P \geq 0.60$) by substituting 20% of steam-flaked corn with whole shelled corn. It was concluded that 3 of the heifers died from complications secondary to respiratory disease and 1 died from sudden death. The mortality rate of the heifers fed 20% and 0% whole shelled corn was 0.46% and 0.15%, respectively.

Effects of Wet Distiller's Grains Plus Solubles. Increasing concentrations of wet distiller's grains plus solubles in steam-flaked corn-based diets decreased ($P < 0.01$) final body weight linearly, tended to decrease ($P = 0.10$) average daily gain linearly, tended to increase ($P = 0.08$) dry matter intake linearly, and increased ($P = 0.02$) feed to gain ratio linearly (Table 2). Addition of increasing amounts of wet distiller's grains plus solubles to steam-flaked corn-based diets

tended to decrease hot carcass weights linearly (P = 0.09), but did not affect ($P \geq 0.18$) other carcass characteristics. Morbidity and mortality of heifers were not affected ($P \geq 0.16$) by the addition of wet distiller's grains plus solubles to steam-flaked corn-based diets. The mortality rates among heifers fed 30, 15, or 0% wet distiller's grains with solubles were 0.15%, 0.15%, and 0.31%, respectively.

Discussion

Adding Whole Shelled Corn to Steam-flaked Corn-based Diets. Greater dry matter intake of heifers fed steam-flaked corn-based diets containing 20% versus 0% whole shelled corn was possibly due to decreased ruminal starch digestion and altered ruminal fermentation. In a companion experiment, Tracey et al. (2011) reported 4.3% greater pH, 4.5% greater acetate, 7.4% lower propionate, and a 12% higher acetate to propionate ratio within the rumen of heifers consuming steam-flaked corn-based diets containing 20% versus 0% whole shelled corn. Infusion of propionate into the rumen has been shown to depress feed intake, and a decrease in ruminal propionate in the 20% versus 0% whole shelled corn diet could explain some of the differences in dry matter intake. Additionally, the increase in dry matter intake when 20% whole shelled corn replaced steam-flaked corn could be due to a decrease in the energy availability of the diet. A reduction in dry matter intake by feedlot cattle consuming extensively processed compared with less processed corn has been well documented (Owens et al., 1997; Leibovich et al., 2009).

Steam-flaked corn-based diets have negative implications on carcass quality grades when compared to diets with less processed grain (Owens and Gardner, 2000). Steam flaking changes the physical and chemical characteristics of corn and enhances starch availability in the rumen. Increased deposition of fat that is related to decreased post-ruminal digestion of starch may in part explain the negative impacts of steam-flaking on quality grades (Owens and Gardner, 2000). However, the reduction in the percentage of carcasses grading USDA choice or better, and the higher percentage of carcasses grading USDA select in response to substituting 20% of the steam-flaked corn with whole shelled corn is not congruent with these thoughts.

Adding Wet Distiller's Grains plus Solubles to Steam-flaked Corn-based Diets. The tendency for a linear increase in dry matter intake with the addition of higher concentrations of wet distiller's grains plus solubles aligns with previous research (May et al., 2009). However, other researchers have reported either no differences (Depenbusch et al., 2008) or decreases (May et al., 2010) in dry matter intake with inclusion of wet distiller's grains plus solubles in finishing diets. According to May et al. (2009), different responses for dry matter intake among various studies could be due to differences in the composition of wet distiller's grains plus solubles. Different responses among studies may also be explained by different approaches to balancing diets. In the current study, all diets were balanced to be similar in ruminally degradable protein and fat, but not similar in crude protein and energy concentration. Hicks et al. (2007) reported that the energy value of wet distiller's grains plus solubles is approximately 86% of the energy value of steam-flaked corn, and previous research (Leibovich et al., 2009; May et al., 2009) showed lower performance-calculated net energy values for corn-based diets when wet distiller's grains plus solubles were added. Therefore, observed increases in dry matter intake with the addition of higher concentrations of wet distiller's grains plus solubles were perhaps a function of dietary energy intake. The tendency for average daily gain of heifers to decrease as the concentrations of wet distiller's grains plus solubles increased in the diet is consistent with results observed by other researchers (Vander Pol et al., 2008; Corrigan et al., 2009; May et al., 2010). The combined effects of dry matter intake and average daily gain with increasing amounts of wet distiller's grains plus solubles in steam-flaked corn-based diets resulted in poorer feed conversion (greater feed to gain ratio) as the concentration of wet distiller's grains plus solubles increased.

Conclusion. Performance of heifers in this feedlot finishing experiment was relatively poor, and the causing factor could have been winter weather. Management and the size of the cattle when they were placed on feed could also have contributed to lack of optimal performance. The results of this study demonstrated that substituting steam-flaked corn with 20% whole shelled corn in finishing diets did not affect animal performance and feed conversion, but decreased carcass quality. In contrast, substituting steam-flaked corn in finishing diets with increasing amounts of wet distiller's grains plus solubles decreased animal performance and feed efficiency (increased feed to gain ratio), but did not affect carcass characteristics. Limited responses to the substitution of steam-flaked corn with 20% whole shelled corn could in part explain the lack of an interaction between whole shelled corn and wet distiller's grains plus solubles. Thus, it is not clear if grain processing could be reduced in finishing diets containing wet distiller's grains plus solubles without affecting feedlot cattle performance and feed conversion.

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Table 1. Composition of dietary treatments in a 2 by 3 factorial arrangement with whole shelled corn (WSC) and wet distiller's grains plus solubles (WDGS) replacing steam-flaked corn

	0% WSC			20% WSC		
Item	0% WDGS	15% WDGS	30% WDGS	0% WDGS	15% WDGS	30% WDGS
Ingredient, % dry basis						
Steam-flaked corn	78.5	67.7	56.8	58.5	47.7	36.8
Whole shelled corn	-	-	-	20.0	20.0	20.0
WDGS	-	15.0	30.0	-	15.0	30.0
Wheat silage	9.0	9.0	9.0	9.0	9.0	9.0
Soybean meal	7.0	4.0	1.0	7.0	4.0	1.0
Supplement[1]	2.5	2.5	2.5	2.5	2.5	2.5
Tallow	2.0	1.0	-	2.0	1.0	-
Urea	1.00	0.85	0.75	1.00	0.85	0.75
Nutrient[2], % dry basis						
Crude protein	14.5	16.3	18.3	14.2	16.3	18.1
Neutral detergent fiber	13.3	16.5	18.9	13.9	16.5	19.6
Acid detergent fiber	7.2	9.7	10.7	7.5	8.8	10.5
Ether extract	4.4	5.1	5.8	4.8	5.2	5.7
Potassium	0.74	0.78	0.80	0.73	0.78	0.78
Calcium	0.70	0.70	0.69	0.67	0.72	0.68
Phosphorus	0.25	0.32	0.39	0.24	0.32	0.37
Sulfur	0.13	0.21	0.29	0.13	0.21	0.27

[1]Supplement composition: 75.5% limestone; 8.0% potassium chloride; 7.7% salt; 2.9% magnesium oxide; 0.86% zinc sulfate; 0.49% selenium premix (0.06% Se); 0.42% manganese sulfate; 0.31% copper sulfate; 0.036% EDDI (4.4%); 0.034% vitamin E (500 IU/g); 0.028% vitamin A (30,000 IU/g); 0.004% cobalt sulfate; 0.72% Rumensin (176 g/kg monensin; Elanco Animal Health, Indianapolis, IN); 0.48% Tylan (88 g/kg tylosin; Elanco Animal Health); 0.39% MGA-200 (0.44 g/kg melengestrol acetate; Pfizer Animal Health, New York, NY); 2.1% mineral oil.

[2]Nutrient composition analyzed by Servi-Tech Laboratories, Amarillo, TX.

Table 2. Effects of whole shelled corn (WSC) and wet distiller's grains plus solubles (WDGS) substitution in steam-flaked corn-based finishing diets on performance and carcass characteristics of feedlot heifers[1]

	0% WSC			20% WSC				*P*-value			
Item	0% WDGS	15% WDGS	30% WDGS	0% WDGS	15% WDGS	30% WDGS	SEM	WSC × WDGS	WSC	WDGS Linear	WDGS Quad.
Number of pens	6	6	6	6	6	6					
Days on feed	108	108	108	108	108	108					
Initial body weight, lb	920	905	901	906	902	901	39.83	0.47	0.25	0.06	0.50
Final body weight, lb	1206	1189	1178	1216	1198	1187	37.31	0.99	0.11	<0.01	0.66
Dry matter intake, lb/day	16.9	17.4	17.3	17.8	18.0	18.2	0.62	0.81	<0.01	0.08	0.40
Average daily gain, lb/day[2]	2.56	2.63	2.56	2.78	2.67	2.55	0.071	0.23	0.17	0.10	0.55
Feed to gain ratio[3]	6.64	6.62	6.77	6.43	6.78	7.21	0.290	0.25	0.41	0.02	0.71
Hot carcass weight, lb	736	733	727	740	741	730	26.17	0.87	0.30	0.09	0.42
Ribeye area, sq. in.	12.6	13.1	13.0	13.3	13.2	13.0	0.36	0.43	0.20	0.97	0.49
12th rib fat, in.	0.60	0.60	0.55	0.60	0.60	0.59	0.03	0.69	0.67	0.18	0.70
KPH[4] fat, %	3.17	3.14	3.18	3.18	3.20	3.30	0.06	0.67	0.16	0.24	0.43
Yield grade	3.15	2.98	2.93	2.94	2.96	2.95	0.13	0.56	0.41	0.35	0.81
Marbling score[5]	473	496	477	482	470	472	15.61	0.33	0.40	0.78	0.46
Choice or better, %	93.2	89.4	81.7	78.2	86.7	83.5	0.04	0.08	0.07	0.23	0.37
Select, %	6.8	8.2	16.1	21.8	12.2	16.5	0.04	0.14	0.03	0.33	0.18
Abscessed livers, %	2.82	4.94	2.82	5.82	2.71	2.89	0.03	0.43	0.90	0.51	0.87

[1]Treatments were a 2 by 3 factorial arrangement of whole shelled corn (WSC) and wet distiller's grains plus solubles (WDGS) replacing steam-flaked corn.
[2]Average daily gain = (pen weight out – pen weight in)/total head days; head day = number of animals in a pen for that day.
[3]Feed to gain ratio = (dry matter intake/average daily gain).
[4]KPH = Kidney, pelvic, & heart.
[5]400 = Small[0].

Administrator
Clayton Livestock Research Center
New Mexico State University