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Extruded Complete Feed for Finishing Cattle

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Introduction

Steam flaking is the predominant means of processing grains in large commercial feedlots. Compared with dry rolling, steam flaking improves total tract digestibility and feed efficiency by 8 to 15%. In steam-flaked corn diets, alfalfa hay often is used as a source of roughage. A survey of industry consultants showed that the range of roughage levels used is between 4.5 and 13.5%. Roughages are commonly the highest-cost ingredient per unit of energy and are highly prone to shrink. Low roughage levels are desirable, but a modest level must be maintained to ensure rumen health. Cattle, like other species, can be selective in their eating. We proposed that we could achieve a greater level of grain processing with an extruded processed diet than with steam flaking. In addition, a complete extruded diet would ensure that all cattle received the desired ratio of concentrate and roughage.

Experimental Procedures

Seventy-two crossbred yearling heifers (796 ± 11 lb initial body weight) were obtained from a common source and used in a randomized complete block study. Treatments were arranged in a 2 × 3 factorial. Factor one was level of alfalfa hay (2 or 6%), and factor two was degree of processing (steam flaked, moderate-shear, or high-shear extrusion cooking). Shear is defined as the mechanical energy applied to the corn in the extruder. Different levels of shear can be achieved by altering pressure, friction, and retention time in the extruder. Experimental diets included either 82 or 85% corn depending on the level of alfalfa hay used (Table 1). Differences in the physical form of the traditional flaked corn diets and extruded diets are depicted in Figure 1. Heifers were confined to individual pens and fed once daily for 143 days.

In the steam-flaked diets, whole corn was steam treated in a 30-in. × 48-in. × 10-ft. steam chest for 45 minutes and then passed through an 18 × 24-in. flaker mill and processed to a bulk density of 28 lb/bu with an average particle size of 5,961 µm. Steam-flaked corn was then mixed in the appropriate proportion with alfalfa hay, corn steep liquor, and supplement in a stationary paddle mixer. For the extruded diets, cracked corn, alfalfa hay, corn steep liquor, and supplement were added to a corotating, fully-intermeshing, twin-screw extruder (BCTG-62, Bühler AG CH-9240, Uzwil, Switzerland). The ingredients were processed by a combination of mixing, cooking, and agglomerating into a complete extruded feed. Two parameter sets were used to achieve the moderate and high degrees of extrusion cooking.

After 143 days, heifers were weighed and shipped to a commercial abattoir (Tyson Fresh Meats Inc., Emporia, KS). Carcass weights and incidence of liver abscesses were measured at the time of slaughter, and ribeye area; kidney, pelvic, and heart fat; 12th rib fat thickness, USDA yield grade, USDA quality grade, and marbling score were measured after a 24-hour chill.

Forty-eight hours after the time of slaughter, loin sections were removed from the right side of carcasses and transported to the Kansas State University Meat Lab. Vacuum-packaged loin sections were allowed to age in a walk-in cooler for 14 days. Muscle pH and purge loss (i.e., loss of water) were determined following the aging period. Loin sections were then fabricated into steaks and frozen for subsequent analyses. Cooking loss, steak tenderness, lipid oxidation, and analysis of steak color were measured over an 8-day retail display period.

Results and Discussion

Growth performance

Heifers fed either moderate- or high-shear extruded diets consumed 19% less (P=0.01) feed than heifers fed steam-flaked corn diets (Table 2). Likewise, heifers fed the low (2%) alfalfa hay diet consumed 7% less (P=0.01) feed than heifers fed the high (6%) alfalfa hay diet. Average daily gains were not different (P>0.05) among the steam-flaked, moderate-shear, and high-shear extruded diets; however, heifers fed the low (2%) alfalfa hay diet gained 12% less (P=0.02) weight than heifers fed the high (6%) alfalfa hay diet. On average, feed efficiency was 15% greater (P=0.01) for heifers fed the moderate-shear and high-shear extruded diets compared with heifers fed the steam-flaked corn diets. Feed efficiency was similar (P>0.05) between the two alfalfa hay levels.

Carcass characteristics (Tables 3 and 4)

Final body weight and carcass weight were similar (P>0.05) among the steam-flaked, moderate-shear, and high-shear extruded diets. Carcasses from heifers fed the low (2%) alfalfa hay diet were lighter (P=0.02) than carcasses from heifers fed the high (6%) alfalfa hay diet. Incidence of liver abscesses was similar (P>0.05) among the steam-flaked, moderate-shear, and high-shear extruded diets. Interestingly, heifers fed the high (6%) alfalfa hay diet had greater (P=0.01) incidence of condemned livers due to abscesses than heifers fed the low (2%) alfalfa hay diet. Other carcass characteristics including dressed yield; ribeye area; kidney, pelvic, and heart fat; 12th rib fat thickness; USDA yield grade; and USDA quality grade were similar (P>0.05) among treatments. Conversely, marbling score was greater (P=0.01) for heifers fed steam-flaked corn diets compared with the average of the moderate- and high-shear extruded diets.

Meat attributes (Table 5)

Muscle pH was similar (P>0.05) between treatments. Loin sections from heifers fed steam-flaked corn diets retained less (P=0.03) water than loin sections from heifers fed either moderate- or high-shear extruded diets; however, cooking loss, steak tenderness, and lipid oxidation were similar (P>0.05) among treatments. Redness of retail display steaks (Figure 2) decreased after the 8-day display period but was similar (P>0.05) among treatments.

Implications

Extrusion-processed feed improved feed efficiency with no deleterious effects on carcass quality or meat attributes.

Table 1. Composition of finishing diets containing either 2 or 6% ground alfalfa hay

Ingredient, % of dry matter	2% alfalfa hay	6% alfalfa hay
Corn[1]	85.0	81.7
Corn steep liquor	6.6	6.6
Alfalfa hay	2.0	6.0
Limestone	1.7	1.6
Urea	1.2	1.2
Soybean meal	0.6	–
Vitamin/mineral premix	0.7	0.7
Supplement	2.2	2.2
Chemical composition, %		
Dry matter	80.0	80.0
Crude protein	14.0	14.0
Neutral detergent fiber	9.0	10.6
Calcium	0.7	0.7
Phosphorus	0.4	0.4

[1] Corn in steam-flaked diets was processed to 28 lb/bu by using an 18 × 24-in. flaker mill. Corn in the extruded diet was processed along with other ingredients by using a twin-screw extruder.

Table 2. Animal performance of yearling heifers fed either 2 or 6% alfalfa hay in steam-flaked corn diets or in a comparable extruded form

	2% alfalfa hay			6% alfalfa hay				P-value		
Item	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	SEM	Process	Roughage	Process × Roughage
No. of heifers	12	12	12	12	11	12	–	–	–	–
Days on feed	143	143	143	143	143	143	–	–	–	–
Initial BW, lb	796	796	796	796	794	796	11.5	0.97	0.83	0.94
Final BW, lb[1]	1144	1129	1100	1166	1157	1173	25.4	0.66	0.02	0.44
DMI, lb/d	21.8	17.0	16.5	21.8	19.2	18.3	0.75	0.01	0.01	0.14
ADG, lb/d	2.43	2.31	2.12	2.58	2.54	2.65	0.13	0.64	0.02	0.41
Feed:Gain[2]	8.97	7.36	7.78	8.45	7.56	6.91	0.33	0.01	0.24	0.19

1 Final BW = Carcass weight/63.5%.
2 Analyzed as gain:feed but reported as feed:gain

Table 3. Carcass characteristics of yearling heifers fed either 2 or 6% alfalfa hay in steam-flaked corn diets or in a comparable extruded form

	2% alfalfa hay			6% alfalfa hay				P-value		
Item	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	SEM	Process	Roughage	Process × Roughage
Carcass weight, lb	725	717	699	741	734	745	16.1	0.66	0.02	0.44
Dressed yield, %	63.9	63.8	63.5	62.7	64.2	62.9	0.49	0.26	0.27	0.26
Ribeye area, in.^{2}	12.6	13.2	12.3	13.0	12.9	13.0	0.40	0.60	0.32	0.42
Kidney, pelvic, and heart fat, %	2.08	2.04	2.13	2.27	2.14	2.15	0.10	0.68	0.23	0.71
12th rib fat, in.	0.50	0.40	0.44	0.41	0.48	0.45	0.008	0.94	0.85	0.23
Total liver abscess, %	0	0	0	16.7	9.1	25.0	7.9	0.61	0.01	0.61
A+	0	0	0	16.7	0	8.3	5.8	0.37	0.08	0.37
A	0	0	0	0	9.1	0	3.4	0.33	0.29	0.33
A-	0	0	0	0	0	16.7	4.6	0.13	0.15	0.13

Table 4. Yield grade and quality grade of yearling heifers fed either 2 or 6% alfalfa hay in steam-flaked corn diets or in a comparable extruded form

	2% alfalfa hay			6% alfalfa hay				P-value		
Item	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	SEM	Process	Roughage	Process × Roughage
USDA yield grade	3.1	2.5	2.7	2.8	2.9	2.9	0.17	0.47	0.44	0.08
YG 1, %	0	0	0	0	0	0	0	–	–	–
YG 2, %	8.3	50.0	41.7	25.0	27.2	16.7	12.9	0.25	0.33	0.20
YG 3, %	75.0	50.0	50.0	75.0	63.7	75.0	14.0	0.43	0.27	0.67
YG 4, %	16.7	0	8.3	0	0	8.3	6.7	0.37	0.32	0.37
YG 5, %	0	0	0	0	9.1	0	3.4	0.33	0.29	0.33
USDA quality grade, %										
Choice or better	83.3	58.3	66.7	58.3	63.6	58.3	14.2	0.76	0.43	0.57
Select	8.3	33.3	25.0	25.0	27.3	41.2	13.0	0.40	0.40	0.61
No roll	8.3	8.3	8.3	16.7	9.0	0	7.5	0.24	0.62	0.83
Marbling score[1]	538	408	430	499	428	415	26.7	0.01	0.61	0.56

[1] 400 = small, 500 = modest.

Table 5. Meat attributes of yearling heifers fed either 2 or 6% alfalfa hay in steam-flaked corn diets or in a comparable extruded form

	2% alfalfa hay			6% alfalfa hay				P-value		
Item	Steam-flaked corn	Moderate-shear extru-sion	High-shear extrusion	Steam-flaked corn	Moderate-shear extru-sion	High-shear extrusion	SEM	Processing	Roughage	Process × Roughage
Muscle pH	5.49	5.47	5.48	5.47	5.49	5.45	0.015	0.67	0.37	0.33
Purge loss, %	1.5	2.1	1.9	1.7	2.4	2.3	0.24	0.03	0.18	0.83
Cooking loss, %	29.6	26.9	28.9	26.4	22.9	29.8	3.74	0.48	0.48	0.77
Shear force, lb[1]	6.6	7.3	6.8	7.3	7.3	7.1	0.33	0.46	0.35	0.42
Lipid oxidation[2]	0.68	1.06	1.02	0.82	0.89	0.95	0.15	0.23	0.73	0.57

[1] Pounds of force required to shear through 0.5-in. diameter core of steak as determined by Warner-Bratzler shear force.
[2] Thiobarbituric acid reactive substance, expressed as milligrams of malonaldehyde/kg of longissimus muscle.

Figure 1. Physical form of the steam-flaked corn (left) and extruded (right) diets fed to cattle.

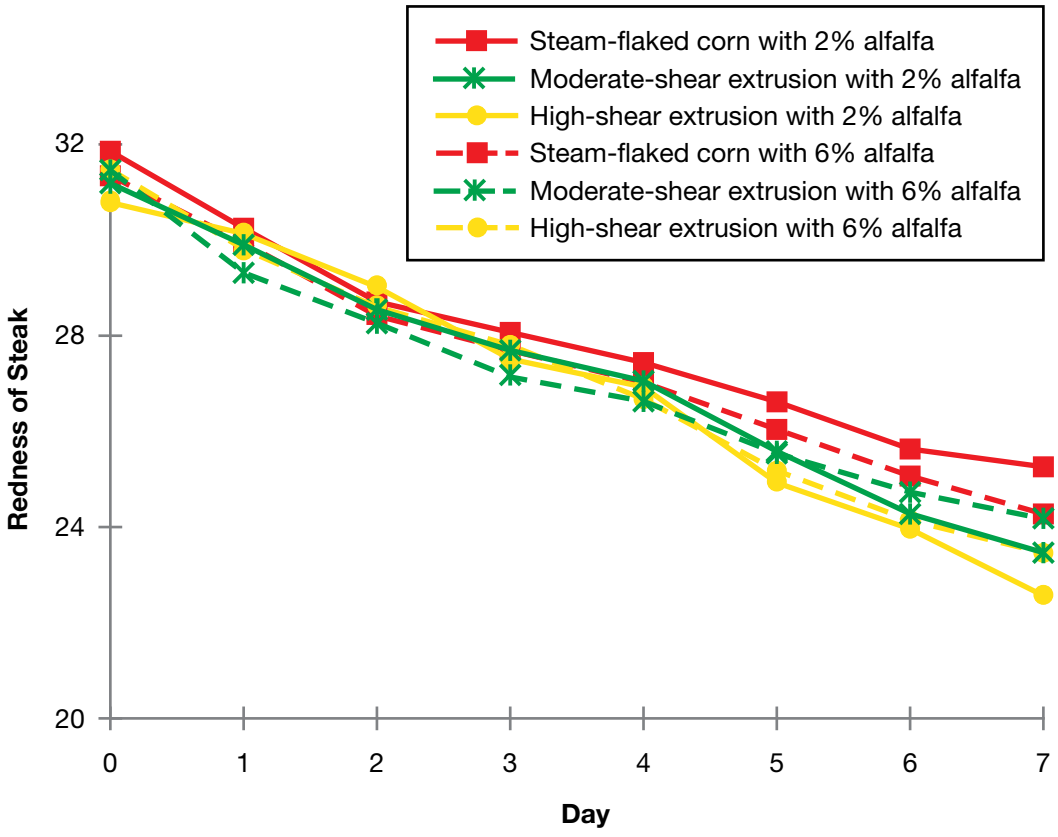

Figure 2. Redness of steaks over an 8-day period in a retail display case as determined by using a Hunter miniscan spectrophotometer.
Arbitrary units; 32 = bright cherry red; 20 = brownish color.