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Effects of Feeding a Return Chewing Gum/Packaging Material Mixture on Performance and Carcass Characteristics of Feedlot Cattle[1]

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ABSTRACT: Seventy-two Simmental-cross growing steers (219 ± 2.4 kg initial BW) were used in a randomized complete block design to evaluate the effects of feeding a return chewing gum/packaging material mixture (G/P) on feedlot performance, carcass characteristics, sensory attributes of meat, and mineral content of beef liver and muscle. Animals were allotted by weight to 12 pens (six/pen). Each pen was assigned one of three dietary treatments: 1) 0% G/P (control), 2) 20% G/P, or 3) 30% G/P (% G/P on a DM basis). Steers were fed their respective diets for an 84-d growing phase and a 112-d finishing phase. The G/P replaced corn silage and corn in the growing and finishing phases, respectively. Eighteen steers (six/treatment) were randomly selected for slaughter at the end of the finishing phase, and carcass measurements, sensory attributes of meat, and mineral content of liver and longissimus muscle were measured. During the growing phase, steers fed G/P-containing diets had improved ($P < .01$) daily DMI, ADG, and gain:feed ratios (G:F) compared with controls. However, due to compensatory gain and the fact that G/P replaced corn in the finishing phase, control steers had increased ($P < .01$) ADG and improved ($P < .05$) G:F vs steers fed G/P-containing diets. Over the entire study (growing and finishing phases) steers fed diets containing G/P and the control had similar performance. Amount of G/P in the diet had no effect ($P > .05$) on carcass characteristics. Steaks from steers fed 20% G/P had improved ($P < .01$) juiciness compared with steaks from steers fed 30% G/P; no other sensory attributes were affected. Aluminum, zinc, and barium content of longissimus muscle and liver were within the normal expected ranges for all treatments. These data indicate that G/P can safely replace at least 30% of growing and finishing diets without impairing feedlot performance or carcass merit.

Key Words: Chewing Gum, Packaging, Steers, Performance, Safety

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Introduction

As the cost of production increases in animal agriculture, producers are looking for alternatives (e.g., byproducts) to reduce feed costs. Researchers have shown that byproducts (e.g., fish meal, blood meal, chemically treated roughage) can replace traditional feedstuffs while maintaining production efficiency. In addition to the benefits of reduced cost of production, feeding byproducts may minimize the solid waste stream entering landfills. As the costs of incineration or disposal in landfills rise, unique byproducts are becoming available for animal feed use. Milton and Brandt (1993) fed a dried bakery product (**DBP**) to finishing steers and found that DBP had an energy value similar to that of corn grain and could be fed at 15% of dietary DM without hampering feedlot performance. Berger et al. (1994) fed a return chewing gum/packaging material mixture (**G/P**) to ruminally cannulated growing steers. They found that G/P can safely replace at least 30% of a corn-alfalfa hay diet for growing steers, resulting in improved DMI and DM digestibility.

The primary objectives of this experiment were to determine 1) the effect of feeding low levels (20 and 30%) of G/P on growth rate, feed intake, and feed efficiency of growing and finishing steers and 2) whether feeding cattle G/P has any effect on carcass characteristics, sensory attributes of meat, and mineral content of liver and longissimus muscle.

Materials and Methods

Growth Phase. Seventy-two Simmental-cross growing steers (219 ± 2.4 kg initial BW) were used in a randomized complete block experiment to evaluate the

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Table 1. Ingredient composition of diets fed to growing steers

	Treatment		
Ingredient, % DM	Control	20% G/P	30% G/P
Corn silage	62	42	32
Corn gluten feed	25	25	25
G/P[a]	0	20	30
CDS[b]	5	5	5
Ground corn	4.55	.93	.20
Soybean meal	.81	3.10	3.36
Blood meal	.43	1.64	1.77
Dicalcium phosphate	.70	.88	1.00
Limestone	.28	.16	.10
Urea	.93	.99	1.27
Trace mineral salt and Se[c]	.28	.28	.28
Rumensin 60	.02	.02	.02
Vitamins A, D, E	.01	.01	.01

[a]G/P = ground (3.175-cm screen) return gum/packaging material mixture.
[b]CDS = condensed distillers solubles.
[c]Contained a minimum percentage of the following minerals: Zn (.35), Mn (.28), Fe (.175), Cu (.035), I (.007), Co (.007), and 86 mg/kg Se.

effects of feeding G/P on ADG, DMI, and feed efficiency. Ingredient composition of the dietary treatments is presented in Table 1. Treatments contained 0 (control), 20, and 30% G/P (DM basis). Diets were balanced to contain 14% CP, .65% Ca, and .45% P. All other nutrients were formulated to meet or exceed NRC (1984) requirements for growing steers. Animals were allotted by weight to 12 pens (six/pen) so that each pen would have a similar initial mean BW. Treatments were randomly allotted to pens within each block (barn location). Cattle were housed on solid concrete floors with a density of 140 m^2 floor space per steer.

Before allotting animals to pens, steers were processed by implanting with Ralgro® (36 mg of zeranol; Pitman-Moore, Terre Haute, IN) and vaccinating with bovine rhinotracheitis, parainfluenza, syncytial virus, 7-way Clostridial, and *Haemophilus somnus* (Bio-Ceutric/Boehringer Ingelhein Animal Health, St. Joseph, MI). On d 84 of the growing phase, steers were reimplanted with Ralgro (36 mg of zeranol) and poured with Warbex (American Cyanamid, Princeton, NJ).

Steers were individually weighed upon initiation of the trial and on 28-d intervals throughout the trial. Average daily gain, DMI, and gain:feed ratio (**G:F**) (ADG ÷ DMI) were determined at each time interval.

Samples of feed ingredients were taken separately before mixing each month. Absolute DM composition was determined and appropriate adjustments in feed rations were made. Dry matter, OM, and Kjeldahl N were determined using AOAC procedures (1990). Neutral detergent fiber and ADF were determined by the procedures of Jeraci et al. (1988) and Goering and Van Soest (1970), respectively. Return chewing gum/packaging material was ground through a 3.175-cm screen in a batch mixer-grinder before incorporation into diets.

Data were analyzed as a randomized complete block (**RCB**) design by ANOVA using the GLM procedure of SAS (1985). Model sums of squares for the RCB design included treatment and block (location in barn). Treatment effects were tested using the following orthogonal contrasts: 1) control vs 20 and 30% G/P and 2) 20 vs 30% G/P. The experimental unit was pen (six steers/pen).

Finishing Phase. Steers from the growing phase were maintained on the same treatments during a 112-d finishing phase feedlot trial. Dietary ingredient composition is presented in Table 2. Steers were adapted from growing to finishing diets over a 3-wk period by gradually replacing corn silage and corn gluten feed with ground corn and high-moisture corn. Diets were balanced to contain 12% CP, .50% Ca, and .30% P. All other nutrients were added to meet or exceed NRC (1984) requirements for finishing steers. Cattle were individually weighed at 28-d intervals and feed samples were processed as in the growing phase. Again, G/P was ground through a 3.175-cm screen in a batch mixer-grinder before incorporation into diets except during the last 28-d interval, when G/P was ground through a 3.81-cm screen in a hammer mill. Performance data for the finishing phase were analyzed as for the growing phase. One steer on the 30% G/P-containing treatment died (d 92) of pneumonia.

Carcass Evaluation. Six steers from each treatment (18 total) were slaughtered (Meat Sciences Laboratory, University of Illinois) at the end of the finishing

Table 2. Ingredient composition of diets fed to finishing steers

	Treatment		
Ingredient, % DM	Control	20% G/P	30% G/P
Corn silage	15	15	15
Corn gluten feed	15	15	15
G/P[a]	0	20	30
Ground corn	29.93	19.93	14.93
High-moisture corn	27	14.3	8
CDS[b]	10	10	10
Corn gluten meal	0	2.7	4
Soybean meal	.41	.41	.41
Urea	.79	.79	.79
Limestone	1.21	1.21	1.21
Potassium chloride	.31	.31	.31
Rumensin 60	.02	.02	.02
Tylosin 40	.01	.01	.01
Trace mineral salt and Se[c]	.31	.31	.31
Vitamins A, D, E	.01	.01	.01

[a]G/P = ground (3.175-cm screen) return gum/packaging material mixture.
[b]CDS = condensed distillers solubles.
[c]Contained a minimum percentage of the following minerals: Zn (.35), Mn (.28), Fe (.175), Cu (.035), I (.007), Co (.007), and 86 mg/kg Se.

phase. Hot carcass weights were obtained from all steers at time of slaughter, at which time a USDA inspector evaluated gross anatomy of the liver, kidney, heart, and lymph glands. In addition, samples of liver tissue were collected and analyzed for aluminum, barium, and zinc (Slavin et al., 1975). After carcasses were chilled 24 h, the following measurements were obtained: 1)longissimus muscle area, taken by direct grid reading of the longissimus muscle at the 12th rib; 2) subcutaneous fat over the longissimus muscle at the 12th rib (subjectively adjusted for unusual fat distribution); 3) kidney, pelvic, and heart fat (**KPH**) as a percentage of carcass weight; and 4) marbling score (USDA, 1989). After aging carcasses for 7 d, steaks from the longissimus muscle were collected, then frozen (−4°C) and later analyzed for sensory and shear analyses. Steaks were cut (2.54 cm), thawed (4°C), and cooked to an internal temperature of 70°C (AMSA, 1978) on a Farberware open-hearth grill monitored by copper constantan thermocouples and a CS S250 Relay Scanner (Campbell Scientific, Logan, UT). Core steak samples (1.27 cm) were served warm to a six-member experienced taste panel. Evaluations by the panel were made on a continuous 15-point scale for overall tenderness, juiciness, beef flavor intensity, off-flavor intensity, and overall desirability as outlined by the AMSA (1978). In addition, Warner-Bratzler shear tests were performed at room temperature on 1.27-cm cores using an Instron Universal Testing Machine (model 1132). Furthermore, samples of the longissimus muscle were analyzed for aluminum, barium, and zinc concentrations (Slavin et al., 1975).

Data collected from carcasses and tissue samples, in addition to sensory analysis, were analyzed as a RCB design with ANOVA using the GLM procedure of SAS (1985). Each animal served as an experimental unit. Again, treatment effects were tested using the following orthogonal contrasts: 1) control vs 20 and 30% G/P and 2) 20 vs 30% G/P.

Results and Discussion

Growth Phase. The G/P fed in this trial averaged 98.3% DM, 97.6% OM, .7% CP, 18.6% NDF, and 15.4% ADF on a DM basis. Return G/P material was added to replace 20 and 30% corn silage in treatments 2 and 3, respectively (Table 1). Due to the low CP content of G/P (approximately .7%), additional soybean meal, blood meal, and urea were added to the G/P-containing diets at the expense of corn in the control diet (Table 1).

Steer performance during the growth phase is presented in Table 3. During the first 28-d interval, ADG, DMI, and G:F increased ($P < .01$) for the G/P-containing diets vs the control. In addition, G:F was improved ($P < .05$) and ADG tended ($P < .10$) to be higher for steers consuming 20% G/P than for steers consuming 30% G/P. Average daily gain and DMI increased ($P < .05$) and G:F tended ($P < .01$) to improve for the G/P-containing diets vs the control in the second 28-d interval. In the third 28-d interval, DMI was higher ($P < .01$) for the G/P containing diets than for the control. Over the entire 84-d growth

Table 3. Effects of return chewing gum / packaging material on growing steer performance[a]

Item	Treatment			SEM	Treatment effect[b]
	Control	20% G/P	30% G/P		
0 to 28 d					
ADG, kg[vz]	1.20	1.67	1.58	.03	.001
DMI, kg/d[v]	5.65	6.21	6.33	.10	.006
G:F[vy]	.21	.27	.25	.004	.001
29 to 56 d					
ADG, kg[w]	.93	1.22	1.27	.09	.060
DMI, kg/d[w]	6.04	6.75	6.55	.19	.085
G:F[x]	.15	.18	.19	.011	.11
57 to 84 d					
ADG, kg	1.32	1.44	1.43	.05	.26
DMI, kg/d[v]	7.22	8.09	8.30	.17	.009
G:F	.18	.18	.17	.009	.74
0 to 84 d					
ADG, kg[v]	1.15	1.44	1.43	.02	.001
DMI, kg/d[v]	6.30	7.02	7.06	.11	.005
G:F[v]	.18	.21	.20	.003	.004

[a]Values reported are least squares means.
[b]Probability of observing a greater *F*-value.
[v,w,x]Contrasts: Treatment 1 vs 2 and 3; [v]$P < .01$; [w]$P < .05$; [x]$P < .10$.
[y,z]Contrast: Treatment 2 vs 3; [y]$P < .05$; [z]$P < .10$.

Table 4. Effects of return chewing gum / packaging material on finishing steer performance[a]

Item	Treatment: Control	20% G/P	30% G/P	SEM	Treatment effect[b]
0 to 28 d					
ADG, kg	1.80	1.59	1.62	.10	.33
DMI, kg/d	8.75	8.90	8.86	.11	.64
G:F[x]	.21	.18	.18	.01	.18
29 to 56 d					
ADG, kg[z]	1.33	1.33	1.02	.09	.085
DMI, kg/d[x]	9.40	9.71	9.71	.13	.22
G:F[z]	.14	.14	.11	.01	.063
57 to 84 d					
ADG, kg[z]	1.60	1.62	1.25	.11	.090
DMI, kg/d	9.10	9.88	9.26	.31	.26
G:F[xz]	.18	.16	.13	.01	.051
85 to 112 d					
ADG, kg	1.00	.97	.99	.10	.98
DMI, kg/d	9.47	9.77	9.24	.31	.53
G:F	.13	.12	.14	.01	.45
0 to 112 d					
ADG, kg[vy]	1.43	1.38	1.22	.03	.004
DMI, kg/d	9.18	9.56	9.27	.14	.21
G:F[w]	.16	.15	.14	.004	.020

[a]Values reported are least squares means.
[b]Probability of observing a greater *F*-value.
[v,w,x]Contrast: Treatment 1 vs 2 and 3; [v]$P < .01$; [w]$P < .05$; [x]$P < .10$.
[y,z]Contrast: Treatment 2 vs 3; [y]$P < .01$; [z]$P < .10$.

phase, ADG, DMI, and G:F were increased ($P < .01$) for the G/P-containing diets vs the control. This translated into a 25% increase in ADG, a 12% increase in DMI, and ultimately a 12% improvement in feed efficiency (G:F). These data suggest that G/P improved the acceptability of the corn silage-based diet, resulting in a higher DMI. The improved DMI may be attributable to the fact that the energy in G/P (sugar) is more available than the energy in the corn silage it replaced. It seems that the improved ADG noted in steers consuming G/P-containing diets can be attributed to their increased DMI. The return gum/packaging material contains approximately 70% sugar (Wm. Wrigley Jr. Company, Chicago, IL). Of this sugar component, one-third is estimated to be sorbitol. Fontenot and Huchette (1993) found that supplementation of sorbitol (20 to 40 g/d) to diets high in corn silage content increased feed efficiency of finishing feedlot cattle in two of three experiments. Likewise, Daniels et al. (1981) noted improved performance of young dairy calves fed supplemental sorbitol (20 g/d). However, when Boyles and Richardson (1993) supplemented sorbitol (30 g/d) to a steam-flaked grain sorghum-based diet only modest improvements in feed efficiency and daily gain (3.7 and 3.4%, respectively) by finishing steers were reported. The improved G:F noted in the present study may, indeed, be attributable to the supplemental sorbitol. Sorbitol intakes were between 400 and 600 g/d.

However, the improved performance could also be attributable to the enhanced DMI. After the energy requirements of maintenance are met, excess energy is partitioned into growth (performance) of the animal. Furthermore, as more energy becomes available, a smaller proportion of the energy intake is required for maintenance and the efficiency of gain improves.

Finishing Phase. As in the growing phase, G/P was added at 20 and 30% of dietary DM. Return gum/packaging material replaced a portion of ground corn and high-moisture corn in the control treatment. The same supplement was used in all diets; however, corn gluten meal was added to the G/P-containing diets to give each treatment a similar percentage of CP.

Steer performance during the finishing phase is presented in Table 4. During the first 28-d interval, ADG was numerically greater (but not statistically significant, $P > .10$) for the control diet vs the G/P-containing diets. This tended ($P < .10$) to increase G:F for the control diet. In the second 28-d interval, DMI tended ($P < .10$) to be higher for the G/P-containing diets than for the control. In addition, ADG and G:F tended ($P < .10$) to be higher for steers consuming 20 vs 30% G/P. During the third 28-d interval, G:F tended ($P < .10$) to be improved for the control vs the G/P-containing diets. Again, ADG and G:F tended ($P < .10$) to be improved for steers consuming 20 vs 30% G/P.

After an evaluation of the performance data for the first 84 d, the authors concluded that the packaging

Table 5. Effects of return chewing gum / packaging material on feedlot steer performance[a]

Item	Treatment			SEM	Treatment effect[b]
	Control	20% G/P	30% G/P		
ADG, kg[z]	1.34	1.42	1.32	.02	.030
DMI, kg/d[y]	7.80	8.34	8.16	.09	.018
G:F	.17	.17	.16	.004	.26

[a]Combined growing and finishing phases. Values reported are least squares means.
[b]Probability of observing a greater *F*-value.
[y]Contrast: Treatment 1 vs 2 and 3; $P < .01$.
[z]Contrast: Treatment 2 vs 3; $P < .05$.

material in the G/P-containing diets was having more of a roughage effect than expected. Thus, for the last 28-d interval, the level of corn silage was reduced from 15% to 5% in the 20% G/P diet and all of the corn silage was removed from the 30% G/P diet. In both instances, corn silage was replaced with whole shelled corn. During the fourth 28-d interval, no differences ($P > .10$) were found in finishing steer performance. Over the 112-d finishing phase, steers fed the control diet gained 10% faster than steers fed G/P-containing diets. In addition, control steers had improved G:F ($P < .05$) relative to steers fed the G/P-containing diets, resulting in a 13% improvement in feed efficiency. Furthermore, steers fed 20% G/P had better ($P < .01$) ADG compared to steers fed the 30% G/P diet, resulting in a 13% improvement in ADG. As mentioned previously, the data suggested that the packaging material component of G/P had more of a roughage effect than expected, especially in the 30% G/P diet. This may have resulted in slower ruminal turnover by steers fed the G/P-containing diets. This could cause a higher proportion of digestible carbohydrate to be fermented rather than hydrolytically digested and absorbed from the small intestine, thus resulting in a less efficient utilization of available carbohydrate. The reduced performance of G/P-fed steers in the finishing phase also could be related to the fact that G/P replaced corn in the control diet. In addition, the improved performance of the control steers during the finishing phase may be attributed to compensatory gain resulting from the poorer performance of these steers fed the control diet compared to those fed the G/P diets in the growing phase.

Steer performance for the combined growing and finishing phases is presented in Table 5. Steers fed G/P-containing diets had a higher ($P < .01$) DMI vs the control (8.25 vs 7.80 kg/d). Feed efficiency was similar for all treatments. Average daily gain was greater ($P < .05$) for steers consuming 20 vs 30% G/P. Although the statistical comparison was not made, steers consuming 20% G/P had an improved ADG vs the control (1.42 vs 1.34 kg/d; SEM = .02).

Carcass Evaluation. In general, the level of dietary G/P did not have an effect on USDA carcass measurements (Table 6). However, longissimus muscle area tended ($P < .10$) to be larger for steers consuming 20 vs 30% G/P as a result of heavier carcass weights. Overall, steers graded well, having an average quality grade of low Choice and yield grade of 2.

Sensory attributes of ribeye steaks are presented in Table 7. Longissimus steaks from G/P-fed steers had

Table 6. Effects of return chewing gum / packaging material on USDA carcass measurements[a]

Item	Treatment			SEM	Treatment effect[b]
	Control	20% G/P	30% G/P		
Hot carcass wt, kg	315.8	328.1	306.6	9.2	.29
Dressing percentage	62.8	63.6	62.1	.62	.28
Backfat, cm	.70	.85	.70	.11	.58
LMA, cm^2[cz]	77.6	80.9	74.0	2.3	.14
KPH, %[d]	1.65	1.41	1.47	.18	.65
Yield grade	2.3	2.5	2.4	.17	.89
Marbling score	1025	1056	1021	35.0	.75

[a]Values are least square means.
[b]Probability of observing a greater *F*-value.
[c]LMA = longissimus muscle area at the 12th rib.
[d]KPH = kidney, pelvic, and heart fat.
[e]Marbling score: $Small^0$ = 1000, $Small^{50}$ = 1050, etc.
[z]Contrast: Treatment 2 vs 3, $P < .10$.

Table 7. Effects of return chewing gum / packaging material on sensory attributes of ribeye steaks[a]

Item	Treatment			SEM	Treatment effect[b]
	Control	20% G/P	30% G/P		
Tenderness[c]	8.99	9.71	8.47	.61	.38
Juiciness[c,y]	9.39	10.16	8.56	.27	.005
Beef flavor[c]	10.02	10.27	9.91	.21	.50
Off-flavor[c]	14.95	14.99	14.76	.12	.38
Overall palatability[c,z]	9.40	10.15	8.86	.43	.15
Shear force, kg/cm[d]	4.01	3.79	3.99	.44	.92

[a]Values are least squares means.
[b]Probability of observing a greater *F*-value.
[c]Evaluated by a trained sensory panel on a 15-cm continuous scale; 15 = juicy, tender, greater beef flavor, no off-flavors, greater palatability.
[d]Warner-Bratzler shear test to estimate tenderness.
[y,z]Contrast: Treatment 2 vs 3: [y]$P < .01$, [z]$P < .10$.

sensory attributes similar to steaks from control steers. However, steaks from steers fed 20% G/P were more ($P < .01$) juicy than those of steers fed 30% G/P. This resulted in a trend ($P < .10$) for improved palatability of steaks from steers fed 20% G/P vs those from steers fed 30% G/P. This may be attributed to the slightly higher marbling score (Table 6) of steers fed 20 vs 30% G/P.

Concentrations of aluminum, zinc, and barium in the longissimus muscle were similar ($P < .05$) across treatments (Table 8). On the other hand, aluminum concentration in the liver was higher ($P < .05$) in the control steers vs the average of steers fed G/P-containing diets (11.4 vs 6.5 mg/kg). Tissue concentrations of aluminum are in the expected range for normal beef (Valdivia et al., 1978; Sherlock, 1988; Greger, 1991). Mean values for the aluminum concentration in beef muscle are in the range of .2 to 4 mg/kg (Sherlock, 1988; Greger, 1991). Moreover, Valdivia et al. (1978) noted aluminum concentrations of 3.8 to 5.4 mg/kg in fresh beef longissimus muscle and 5.7 to 11.2 mg/kg in fresh beef liver. In this study, they fed growing steers a corn-based diet with supplemental aluminum up to 1,200 mg/kg. After 84 d on feed, steers were slaughtered. No differences ($P > .05$) in liver, kidney, muscle, or brain tissue concentrations of aluminum were noted between steers fed supplemental aluminum (source: soluble aluminum chloride) and the control.

In conclusion, growing steers fed 20 or 30% G/P had improved ADG, DMI, and G:F compared to growing steers fed a control feedlot diet. During the finishing phase, control steers had improved ADG and feed efficiency, probably due to compensatory gain and the fact that G/P replaced corn in the finishing-phase diets. Over the complete study (growing and finishing phases) steers fed diets containing G/P had higher DMI than control steers. In addition, steers fed 20% G/P had greater ADG than steers fed 30% G/P. Although steers consuming both G/P-containing diets had feedlot performance similar to that of control steers, those steers consuming 20% G/P seemed to have superior

Table 8. Effects of return chewing gum / packaging material on the concentration of aluminum, zinc, and barium in the longissimus muscle and liver (on a fresh-weight basis)[a]

Item	Treatment			SEM	Treatment effect[b]
	Control	20% G/P	30% G/P		
Longissimus muscle concentration, mg/kg					
Aluminum	3.5	7.2	6.0	1.33	.17
Zinc	27.8	28.6	27.8	1.43	.90
Barium	5.1	5.8	6.8	1.49	.71
Liver concentration, mg/kg					
Aluminum[y]	11.4	6.9	6.0	1.76	.11
Zinc	30.3	31.7	31.8	2.50	.89
Barium	3.6	4.8	4.1	1.19	.76

[a]Values are least squares means.
[b]Probability of observing a greater *F*-value.
[y]Contrast: Treatment 1 vs 2 and 3: $P < .05$.

performance. The USDA carcass measurements and sensory attributes of ribeye steaks were similar for control steers and steers fed G/P-containing diets.

Implications

These data are interpreted to show that feedlot steers can be safely fed a diet containing up to 30% of a return chewing gum/packaging material mixture without impairment of feedlot performance. In growing diets, replacing corn silage with the chewing gum/packaging material mixture can improve daily gain, feed intake, and feed efficiency.

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