Influence of Tempering on the Feeding Value of Rolled Corn in Finishing Diets for Feedlot Cattle

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ABSTRACT: Crossbred yearling steers (n = 125; 372 kg) were used in a 109-d finishing trial. Steers were fed an 88% concentrate diet containing 65% corn (DM basis) as 1) dry rolled corn (DRC); 2) tempered rolled corn (TRC), 43 mg surfactant (SarTemp®)/kg corn; 3) TRC, 172 mg surfactant/kg corn; 4) TRC, 430 mg surfactant/kg corn; and 5) steam-flaked corn (SFC). Corn moisture was greater (3.5%, $P < .01$) for TRC than for DRC but less (10%, $P < .05$) than for SFC. Starch enzymatic reactivity was less for TRC than for either DRC (18%, $P < .05$) or SFC (42%, $P < .01$). Tempering increased the integrity of rolled corn and reduced the amount of particles less than 2 mm in diameter by 54% ($P < .01$). Steam flaking corn increased ($P < .01$) proportion (78%) of the grain having a particle size distribution of greater than 8 mm, as compared with TRC (25%) and DRC (3%). Compared with DRC, tempering enhanced ($P < .10$) ADG (9%), feed efficiency (5%), and dietary NE (3%). Daily weight gain was similar ($P > .10$) for TRC and SFC. Feed efficiency ($P < .10$) and dietary NE ($P < .01$) were greater (6%) for SFC than for TRC. There were no differences ($P > .10$) between DRC and TRC in ruminal and total tract digestion of OM, N, and starch, and in ruminal microbial efficiency. Ruminal digestion of OM decreased (linear effect, $P < .05$) and ruminal microbial efficiency increased (linear effect, $P < .05$) with increasing surfactant concentration. Ruminal digestion of OM and starch, and flow of nonammonia N to the small intestine were greater (31, 56, and 14%, respectively, $P < .01$) for SFC than for TRC. Postruminal and total tract digestion of OM, N, and starch, and dietary DE were greater ($P < .01$) for SFC than for TRC. We concluded that tempering corn will enhance animal performance. Increasing the concentration of surfactant used in tempering may enhance ruminal microbial efficiency and lean tissue growth.

Key Words: Maize, Processing, Tempering, Cattle, Performance, Metabolism

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Introduction

Tempering grain before processing has become a common practice in the feedlot industry. Tempering refers to the softening of the grain kernel that occurs following the addition of 4 to 8% moisture. Surfactants or wetting agents typically are added to the water during tempering to accelerate the rate of moisture uptake by the kernel. The primary objective with tempering is to lower energy costs and reduce the number of fine particles produced during grain processing. However, tempering may also enhance digestive function and the feeding value of corn. In a previous study (Zinn, 1988), we observed that, compared with dry rolling corn (**DRC**), tempering and rolling corn (**TRC**) enhanced ruminal microbial efficiency 19%, total tract starch digestion 6.5%, and DE value of the diet 5.2%. The improved microbial efficiency seemed to be directly related to the sarsaponin surfactant used to temper the corn. The objective of this study was to evaluate the influence of tempering on the feeding value of corn.

Experimental Procedures

Trial 1. Crossbred yearling steers (n = 125; approximately 25% Brahman breeding with the remainder represented by Hereford, Angus, Shorthorn, and Charolais breeds in various proportions) with an average initial weight of 372 kg were used in a 109-d finishing trial. Steers were blocked by weight and randomly allotted within weight groupings to 25 pens (five steers/pen). Pens were 43 m^2 with 22 m^2 of overhead shade, automatic waterers, and 2.4-m fence-line feed bunks. The trial was initiated on December 27, 1995. Average daily minimum temperature was 9.2°C and maximum air temperature was 26.1°C. Average daily relative humidity was 44.5%. Total

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carcasses were chilled for 48 h, the following measurements were obtained: 1) longissimus muscle area (ribeye area), taken by direct grid reading of the eye muscle at the 12th rib; 2) subcutaneous fat over the loin eye muscle at the 12th rib taken at a location ¾ the lateral length from the chine bone end; 3) kidney, pelvic, and heart fat (**KPH**) as a percentage of carcass weight; and 4) marbling score (USDA, 1965). Retail yields (boneless, closely trimmed retail cuts from the round, loin, rib, and chuck as a percentage of carcass weight) were estimated from measures of carcass weight, longissimus muscle area, subcutaneous fat thickness, and KPH according to USDA (1965).

Estimates of steer performance were based on pen means. Assuming the primary determinant of energy gain is weight gain, the energy gain was calculated with the following equation: $EG = (.0493BW^{.75})ADG^{1.097}$, where **EG** is the daily energy deposited (Mcal/d), and BW is the mean body weight (NRC, 1984). Maintenance energy expended (Mcal/d, **EM**) was calculated with the following equation: $EM = .077W^{.75}$ (NRC, 1984). Dry matter intake is related to energy requirements and dietary NE_m according to the following equation: $DMI = (EM/NE_m) + (EG/(.877NE_m - .41)$. Hence, the NE value of the diets for maintenance and gain were obtained by means of the quadratic formula $\left(x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}\right)$, where $a = -.877DMI$, $b = .877EM + .41DMI + EG$, and $c = -.41EM$, and $NE_g = .877NE_m - .41$. The trial data were analyzed based on a randomized complete block experimental design (Hicks, 1973). Treatment effects were separated into the following contrasts: DRC vs TRC; linear and quadratic effects of surfactant level; and TRC vs SFC.

Trial 2. Holstein steers ($n = 5$; 454 kg) with cannulas in the rumen and proximal duodenum (Zinn and Plascencia, 1993) were used in a 5 × 5 Latin square experiment. Dietary treatments were the same as in Trial 1 (Table 1), with the inclusion of .4% chromic oxide as digesta marker. Dry matter intake was restricted to 7.1 kg/d. Diets were fed in equal portions at 0800 and 2000 daily. The five experimental periods consisted of a 10-d diet adjustment period followed by a 4-d collection period. During the collection period, duodenal and fecal samples were taken from all steers, 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. Individual samples consisted of approximately 700 mL of duodenal chyme and 200 g (wet basis) of fecal material. Samples from each steer and within each collection period were composited for analysis. During the final day of each collection period, ruminal samples were obtained from each steer via the ruminal cannula at 4 h after feeding. Ruminal fluid pH was determined on fresh samples. Samples were strained through four layers of cheesecloth. Two milliliters of freshly prepared 25% (wt/vol) meta-phosphoric acid was added to 8 mL of strained ruminal fluid. Samples were then centrifuged (17,000 × g for 10 min), and supernatant fluid was stored at −20°C for VFA analysis. Upon completion of the trial, ruminal fluid was obtained from all steers and composited for isolation of ruminal bacteria via differential centrifugation (Bergen et al., 1968). Samples were subjected to all or part of the following analyses: DM (oven drying at 105°C until no further weight loss); ash, Kjeldahl N, ammonia N (AOAC, 1975); purines (Zinn and Owens, 1986); VFA concentrations of ruminal fluid (gas chromatography; Zinn, 1988); chromic oxide (Hill and Anderson, 1958), and starch (Zinn, 1990). Duodenal flow and fecal excretion of DM were calculated based on marker ratio, using chromic oxide. Microbial organic matter (**MOM**) and microbial N (**MN**) leaving the abomasum was 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 contributions. Methane production (mol/mol glucose equivalent fermented) was estimated based on the theoretical fermentation balance for observed molar distribution of VFA (Wolin, 1960). The trial data were analyzed based on a 5 × 5 Latin square experimental design (Hicks, 1973). Treatment effects were separated into the following contrasts: DRC vs TRC; linear and quadratic effects of surfactant level; and TRC vs SFC.

Results and Discussion

Treatment effects on physiochemical characteristics of corn are shown in Table 2. The moisture content of TRC was 3.5 percentage units higher ($P < .01$) than that of DRC. This increase in moisture corresponds closely with the amount of water added to the corn during tempering (3.8 g water/100 g corn). Increasing the level of surfactant beyond 43 mg/kg corn did not further enhance moisture content ($P > .10$). Steaming before flaking increased ($P < .05$) the moisture content of corn more than did tempering alone. Enzymatic reactivity of starch was lower for TRC than for either DRC (18%, $P < .05$) or SFC (42%, $P < .01$). In a previous study (Zinn, 1988), enzymatic starch reactivity was similar for TRC and DRC. Lower starch reactivity for TRC than for DRC was due to moisture-induced softening of the kernel, which caused less heat generation during rolling.

As expected, tempering before rolling increased the integrity of the kernel during rolling over that of dry

Table 2. Influence of processing on characteristics of corn

Item	Dry rolled corn	Tempered rolled corn with surfactant, mg/kg corn[a]			Steam flaked corn	SD
		43	172	430		
DM, %[bc]	86.53	82.76	83.28	83.07	81.25	1.67
Starch, %	69.56	70.75	69.77	70.65	70.57	2.04
REAC, %[def]	13.62	11.10	11.00	11.50	19.42	1.08
Corn particle size (mm), % total						
8[bf]	2.82	22.64	27.01	24.50	77.97	12.07
4[ef]	41.37	54.17	48.43	45.63	16.54	8.18
2[bf]	41.43	17.54	18.08	19.91	3.52	6.59
1[ef]	8.84	3.50	4.47	6.05	1.07	3.20
.5[ce]	3.11	1.08	1.25	1.94	.39	1.37
.25	1.28	.58	.52	1.11	.25	.82
<.25	1.15	.49	.25	.86	.25	.58

[a] SarTemp® (Sartec Corp., Auoka, MN).

[b] Dry rolled vs tempered corn, $P < .01$.

[c] Steam-flaked vs tempered corn, $P < .05$.

[d] Starch reactivity, % total starch, a measure of starch solubilization. Grains were ground to pass through a 20 mesh screen before enzymatic digestion for 4 h using amyloglucosidase.

[e] Dry rolled vs tempered corn, $P < .05$.

[f] Steam-flaked vs tempered corn, $P < .01$.

rolling alone. Thus, the amount of particles less than 2 mm in diameter was reduced by 54% ($P < .01$). The influence of tempering on the particle size of rolled corn has not been reported previously. However, Christen et al. (1996) observed that tempering reduced the number of particles <2 mm in diameter in rolled barley. Steam flaking corn increased ($P < .01$) proportion of the grain having a particle size distribution of greater than 8 mm (78 vs 25, and 3%, respectively, for SFC, TRC, and DRC).

Treatment effects on growth performance response of feedlot cattle is shown in Table 3. There were no effects of surfactant concentration on steer growth performance. Compared with DRC, tempering enhanced ($P < .10$) ADG (9%), feed efficiency (5%), and dietary NE (3%). Likewise, Rush et al. (1993) observed that tempering corn before rolling enhanced ADG (10%) and feed efficiency (10%). This improvement in growth performance may have been due in part to tempering effects on corn particle size (Secrist et al., 1996). Zinn (1988) did not observe an influence of tempering corn on ADG. However, consistent with the present trial, tempering increased feed efficiency and dietary NE (4%). Similar improvements (4%) in dietary NE that were due to tempering have also been reported for barley-based diets (Bradshaw et al., 1996).

Daily weight gain was similar ($P > .10$) for TRC and SFC. However, feed efficiency ($P < .10$) and dietary NE ($P < .01$) were greater (6%) for SFC than for TRC. Given that the NE_m and NE_g values of SFC are 2.38 and 1.67 Mcal/kg , respectively (NRC, 1984), then the corresponding NE values for DRC and TRC using the replacement technique are 2.07 and 1.41, and 2.17 and 1.50 Mcal/kg, respectively. Thus, tempering and steam flaking increased the NE_m value of corn by 5 and 15%, respectively. These increases in NE values of corn as a result of tempering are in close agreement with previous work at this center (Zinn, 1988). The increases in NE that were due to steam flaking are also in close agreement with previous studies (Matsushima and Montgomery, 1967; Lee et al., 1982; Ramirez et al., 1985; Zinn, 1987, 1988; Zinn et al., 1995). In contrast, the expected relative advantage in NE_m of SFC vs DRC is only 6% based on NRC (1984) and 4% based on NRC (1996).

Treatment effects on carcass characteristics of feedlot steers are shown in Table 4. Surfactant concentration did not influence ($P > .10$) carcass weight. Carcass weights were greater (3%, $P < .10$) for TRC than for DRC. Carcass weights were similar ($P > .10$) for TRC and SFC. There were no treatment effects ($P > .10$) on dressing percentage. Longissimus muscle area increased (linear effect, $P < .10$) with increasing surfactant concentration. Longissimus muscle area was slightly greater (4%, $P < .01$) for TRC than for SFC. The basis for this effect is not certain. External fat thickness was greater (27%, $P < .05$) for DRC than for TRC. External fat thickness was similar ($P > .10$) for TRC and SFC. There were no treatment effects on KPH and marbling score. Consistent with differences in external fat thickness, percentage of retail yield was slightly greater (1%, $P < .05$) for TRC than for DRC and SFC. Incidence of liver abscess averaged 24% and was not affected ($P > .10$) by dietary treatments.

Treatment effects on digestive function are shown in Table 5. Consistent with Zinn (1988), tempering did not influence ($P > .10$) ruminal and total tract digestion of OM, N, and starch. Although tempering seemed to increase the NE value of the diet based on growth performance in Trial 1, dietary DE was not affected ($P > .10$) by tempering in Trial 2.

Table 3. Influence of corn processing on growth performance response of feedlot steers (Trial 1)

Item	Dry rolled corn	Tempered rolled corn with surfactant, mg/kg corn[a]			Steam flaked corn	SD
		43	172	430		
Days on test	109	109	109	109	109	
Pen replicates	4	4	4	4	4	
Live weight, kg[b]						
Initial	368.7	370.4	369.7	375.0	373.6	4.0
Final[c]	530.3	542.2	543.3	558.7	542.2	14.3
Weight gain, kg/d[c]	1.48	1.57	1.58	1.68	1.54	.11
DM intake, kg/d[d]	8.74	8.94	8.99	9.17	8.14	.36
DM intake/gain[ce]	5.91	5.72	5.70	5.46	5.29	.28
Diet net energy, Mcal/kg						
Maintenance[cd]	2.11	2.15	2.15	2.23	2.31	.07
Gain[cd]	1.44	1.48	1.48	1.54	1.62	.06
Observed/expected diet NE						
Maintenance[c]	.98	1.00	1.00	1.03	1.03	.03
Gain[c]	.97	1.00	1.00	1.04	1.04	.04

[a] SarTemp® (Sartec Corp., Auoka, MN).
[b] Initial and final live weights reduced 4% to account for fill.
[c] Dry-rolled vs tempered corn, $P < .10$.
[d] Steam-flaked vs tempered corn, $P < .01$.
[e] Steam-flaked vs tempered corn, $P < .10$.

Ruminal digestion of feed N and starch was not affected ($P > .10$) by surfactant concentration. However, ruminal digestion of OM decreased (linear effect, $P < .05$) and ruminal microbial efficiency increased (linear effect, $P < .05$) with increasing surfactant concentration. Sarsaponin, a steroidal glycoside of sarsasapogenin, derived from *Yucca shidigera*, is the principal active ingredient in the surfactant used to temper the corn in this study. Increases in ruminal microbial efficiency have been a consistent response to sarsaponin supplementation of growing-finishing diets for feedlot cattle (Grobner et al., 1982; Zinn et al., 1983; Zinn, 1988). This effect of sarsaponin on microbial efficiency may be attributed to its antiprotozoal activity (Valdez et al., 1986; Lu and Jorgensen, 1987; Klita et al., 1996). Sarsaponins react with cholesterol in the cell membranes of protozoa and cause lysis. Because bacteria do not contain cholesterol in their cell membranes, they are not directly affected by sarsaponins. However, sarsaponin-induced reductions in protozoal numbers and activity diminishes bacterial predation and increases net microbial N flow to the small intestine (Cheeke, 1998). Postruminal and total tract digestion of OM, N,

Table 4. Influence of corn processing on carcass characteristics of feedlot steers (Trial 1)

Item	Dry rolled corn	Tempered rolled corn with surfactant, mg/kg corn[a]			Steam flaked corn	SD
		43	172	430		
Carcass weight, kg[b]	344.2	350.6	350.9	359.9	349.9	9.8
Dressing percentage	64.9	64.7	64.6	64.4	64.5	.8
Ribeye area, cm[cd]	84.6	85.0	86.1	87.7	82.6	2.0
Fat thickness, cm[e]	1.10	.85	.87	.88	.97	.16
KPH, %[f]	2.25	2.05	2.09	2.19	2.07	.19
Quality grade[g]	4.50	4.46	4.43	4.12	4.45	.31
Retail yield, %[eh]	50.5	51.0	51.1	51.0	50.5	.5
Abscessed livers, %	10.0	16.3	30.0	25.0	15.0	19.3

[a] SarTemp® (Sartec Corp., Auoka, MN).
[b] Dry-rolled vs tempered corn, $P < .10$.
[c] Surfactant linear effect, $P < .10$.
[d] Steam-flaked vs tempered corn, $P < .01$.
[e] Dry-rolled vs tempered corn, $P < .05$.
[f] Kidney, pelvic, and heart fat as a percentage of carcass weight.
[g] Coded: minimum slight = 3, minimum small = 4, etc.
[h] Steam-flaked vs tempered corn, $P < .10$.

and starch were not affected by surfactant concentration.

Ruminal digestion of OM and starch were greater (31 and 56%, respectively, $P < .01$) for SFC than for TRC. Consistent with previous studies (Zinn, 1987, 1988, 1990; Zinn et al., 1995), steam flaking corn did not influence ($P > .10$) ruminal digestibility of feed N. However, flow of nonammonia N to the small intestine was greater (14%, $P < .01$) for SFC than for TRC, because of increased (20%, $P < .01$) net synthesis of microbial N. Consequently, ruminal N efficiency (nonammonia N flow to the small intestine/N intake) was greater (12%, $P < .01$) for SFC than for TRC. Increased ruminal N efficiency is a highly characteristic response to steam flaking corn (Prigge et al., 1978; Zinn, 1987, 1988, 1990; Zinn et al., 1995). Consistent with Zinn (1988), postruminal and total tract digestion of OM, N, and starch, and dietary DE were greater ($P < .01$) for SFC than for TRC.

As in Trial 1, DE value of TRC and SFC can also be determined using the replacement technique. However, because tabular (NRC, 1984) DE values are based on measures at a maintenance level of intake, it is necessary first to adjust the DE values in Table 5 for this differential. The expected DE value of the diet containing SFC is 3.95 Mcal/kg (Table 1). Accordingly, the observed DE values in Table 5 may be standardized by dividing by .92. Given that the DE value of SFC was 4.19 (NRC, 1984), then the DE value of DRC and TRC were 3.66 and 3.63 Mcal/kg,

Table 5. Influence of corn processing on characteristics of digestion in steers (Trial 2)

Item	Dry rolled corn	Tempered rolled corn with surfactant, mg/kg corn[a]			Steam flaked corn	SD
		43	172	430		
Steer wt, kg	493	493	493	493	493	
Intake, g/d						
DM	7,187	6,879	7,075	7,194	7,373	
OM	6,788	6,478	6,670	6,739	6,972	
Starch	3,054	2,765	3,035	3,036	3,296	
N	143.0	143.8	143.6	150.4	148.2	
Gross energy, Mcal/d	31.51	30.16	31.02	31.54	32.32	
Flow to the duodenum, g/d						
OM[bc]	4,747	4,268	4,660	4,975	4,084	123
Starch[de]	1,635	1,359	1,610	1,688	854	287
Nonammonia N[e]	142.5	140.6	144.1	152.3	166.0	12.3
Microbial N[e]	65.3	71.0	68.5	74.8	85.5	7.9
Feed N[df]	77.3	69.7	75.6	77.5	80.5	6.6
Ruminal digestion, %						
OM[be]	39.6	45.1	40.5	37.4	53.9	5.4
Feed N	45.8	51.5	47.4	48.8	46.0	4.3
Starch[e]	46.3	50.9	47.1	44.5	74.2	9.1
MN efficiency[bg]	28.0	24.5	26.0	33.9	23.8	6.0
N efficiency[eh]	1.00	.98	1.00	1.01	1.12	.07
Fecal excretion, g/d						
OM[e]	1,797	1,394	1,470	1,571	1,049	176
N[cd]	43.8	40.6	41.4	45.8	36.6	4.4
Starch[e]	313.1	259.8	328.3	319.4	46.4	81.8
Gross energy, Mcal/d[e]	7.63	7.20	7.52	8.07	5.56	.82
Postruminal digestion, %						
OM[e]	67.0	67.2	68.4	67.7	73.9	3.3
N[e]	70.1	72.1	72.1	70.3	78.1	2.2
Starch[e]	77.5	80.7	79.7	80.6	94.7	6.2
Total-tract digestion, %						
OM[e]	77.9	78.5	78.0	76.6	85.1	2.3
N[e]	69.4	71.8	71.2	69.6	75.5	2.6
Starch[e]	89.7	90.6	89.3	89.4	98.6	2.6
DE, Mcal/kg[e]	3.32	3.34	3.32	3.26	3.64	.03
DE, %[e]	75.74	76.12	75.82	74.38	82.92	2.28

[a] SarTemp® (Sartec Corp., Auoka, MN).
[b] Surfactant linear effect, $P < .05$.
[c] Steam-flaked vs tempered corn, $P < .05$.
[d] Tempering agent, linear effect, $P < .10$.
[e] Steam-flaked vs tempered corn, $P < .01$.
[f] Steam-flaked vs tempered corn, $P < .10$.
[g] Microbial N, g/kg OM fermented.
[h] Nonammonia N leaving the abomasum/N intake.

Table 6. Influence of corn processing on ruminal pH, volatile fatty acid profiles, and estimated methane production (Trial 2)

Item	Dry rolled corn	Tempered rolled corn with surfactant, mg/kg corn[a]			Steam flaked corn	SD
		43	172	430		
pH	6.35	6.47	6.43	6.54	6.34	.31
Ruminal VFA, mol/100 mol						
Acetate	61.1	62.1	62.8	61.1	59.3	3.3
Propionate	23.4	22.8	21.9	23.3	25.8	3.8
Butyrate	10.8	10.3	10.0	10.2	9.9	.7
Methane production[b]	.57	.58	.59	.57	.54	.05

[a] SarTemp® (Sartec Corp., Auoka, MN).

[b] Methane, mol/mol glucose equivalent fermented.

respectively. Based on the relationship between DE and NE_m (NRC, 1984), the NE_m of DRC and TRC in Trial 2 were 2.03 and 2.01 Mcal/kg, respectively.

The NE value of DRC as measured in the metabolism trial (Trial 2) is in close (98%) agreement with the estimate value based on growth performance in Trial 1. However, the NE_m value of TRC in Trial 2 was 93% of the estimate based on growth performance in Trial 1. The basis for the discrepancy between Trials 1 and 2 in estimates of the NE value of TRC is not certain. A general assumption in the calculation of dietary NE based on growth performance is that energy retention is a predictable function of BW and ADG (Garrett, 1980). In Trial 1, carcasses of cattle that received TRC were slightly leaner than for cattle fed DRC and SFC, and had larger longissimus muscle area and lesser external fat. Consequently, energy retention may have been slightly overestimated for that treatment.

Treatment effects on ruminal pH and VFA molar proportions 4 h after feeding are shown in Table 6. There were no treatment effects ($P > .10$) on ruminal pH, which was comparatively high and averaged 6.43. In previous trials that compared DRC vs SFC (Johnson et al., 1968; Zinn, 1987; Zinn et al., 1995), steam flaking corn decreased ruminal pH. There were also no treatment effects ($P > .10$) on ruminal VFA molar proportions or estimated methane production. However, numerically, ruminal propionate was greater (13%) and methane was lower (6%) with steam flaking corn. Even though increased ruminal molar proportions of propionate have been a rather consistent response that is due to steam flaking corn (Galyean et al., 1976; Zinn, 1987; Zinn et al., 1995), there have been reports (Lee et al., 1982) in which no differences in ruminal VFA molar proportions were detected.

Implications

In addition to the primary objective of reducing energy costs during grain processing, tempering corn before rolling may enhance animal growth performance and net energy value of the diet. Improved performance owing to tempering can result from a reduction in the number of fine particles produced during grain processing and enhanced rate of lean body growth. Increasing the concentration of surfactant used during tempering may enhance ruminal microbial efficiency and lean tissue growth. Steam flaking will increase the feeding value of corn by 16% over dry rolling.

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