# Feeding Value of Wet Distillers Byproducts for Finishing Ruminants[1]

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**ABSTRACT:** Yearling and calf finishing trials (replicated over 2 yr) evaluated the feeding value of wet distillers byproducts (wet distillers grains and thin stillage). An additional trial estimated the amount of thin stillage bypassing the rumen when consumed by drinking. Yearlings were 5, 10, and 20% more efficient (linear, $P < .01$; quadratic, $P = .05$), whereas calves were 2, 6, and 14% more efficient (linear, $P < .01$) when fed 5.2, 12.6, and 40.0% (DM basis) wet distillers byproducts, respectively, compared with cattle fed a 79% dry-rolled corn diet. Cattle fed 5.2 or 12.6% wet distillers byproducts, or the dry-rolled corn diet, received similar amounts of protein (crude or metabolizable), which exceeded the metabolizable protein requirement of all cattle. Therefore, differences in efficiency were attributed to differences in energy utilization of the diets. Wet distillers byproducts fed at 5.2, 12.6 and 40.0% contributed 80, 62, and 47% more net energy for gain than corn when fed to yearlings and 17, 33, and 29% more net energy for gain than corn when fed to calves, respectively. Wet distillers byproducts averaged 169% the energy value of corn (2.53 Mcal of $NE_g$/kg) when fed to yearlings and 128% the energy value of corn (1.96 Mcal of $NE_g$/kg) when fed to calves. The increased energy values cannot be explained by increased digestibility, but they may be due to a combination of factors (reduced acidosis, increased energy utilization, yeast end products, etc.) that increase the net energy content of distillers byproducts. Approximately 50% of the thin stillage consumed by drinking bypassed ruminal fermentation. Wet distillers byproducts are efficiently utilized in ruminant finishing diets as a protein and energy source.

Key Words: Corn, Distillers Byproducts, Cattle, Protein, Energy

J. Anim. Sci. 1993. 71:2228–2236

## Introduction

Ethanol production from yeast fermentation of corn yields whole spent stillage, which is separated by screening and pressing or centrifugation, resulting in wet distillers grains and thin stillage. Typically, these two byproducts are dried and marketed together as distillers dried grains with solubles, or they can be marketed separately as distillers dried grains and condensed distillers solubles (AAFCO, 1977). Dried distillers grains are a good source of bypass protein for ruminants (Waller et al., 1980; Firkins et al., 1984; NCRRP, 1984; Aines et al., 1987).

When drying costs increase, use of wet byproducts is more energy- and cost-efficient than use of dried byproducts. Wet distillers grains (Farlin, 1981; DeHaan et al., 1982; Firkins et al., 1985) and thin stillage (Hanke et al., 1983; Aines et al., 1985; Rust et al., 1990) may be efficiently used as protein and energy sources in ruminant diets. However, because moisture content is high, wet byproducts are expensive to transport and readily mold. Feeding distillers byproducts as a source of both protein and energy in feedlot diets enables the byproduct to be utilized rapidly, in a concentrated area, and with fewer cattle. Therefore, experiments were conducted to evaluate mixtures of wet distillers grains and thin stillage, when fed in the same ratio as produced by the alcohol plant, for yearlings and calves fed high-concentrate diets. In addition, the amount of thin stillage that bypassed ruminal fermentation was estimated when it replaced drinking water.

## Materials and Methods

*Byproduct Production.* Distillers byproducts (wet grains and thin stillage) were produced at the University of Nebraska Agricultural Research Development Center farm-scale alcohol plant and transported, every other day, 3 km to the research feedlot.

[1]Published with the approval of the Director as paper no. 10047, Journal Ser., Nebraska Agric. Res. Div.

Received August 13, 1992.

Accepted March 22, 1993.

Table 1. Composition of yearling and calf final finishing diets

| Item | Byproduct level, % of diet DM | | | | |
|---|---|---|---|---|---|
| | Yearling control | Calf control | 5.2 | 12.6 | 40.0 |
| Dry-rolled corn | 79.0 | 76.0 | 79.0 | 72.0 | 45.0 |
| Wet grains | — | — | 3.3 | 7.9 | 25.0 |
| Thin stillage[a] | — | — | 1.9 | 4.7 | 15.0[a] |
| Corn silage | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Alfalfa hay | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Molasses | 5.0 | 5.0 | — | — | — |
| Dry supplement | 6.0 | 9.0 | 5.8 | 5.4 | 5.0 |
| Finely ground corn | — | — | 2.54 | 2.77 | 2.40 |
| Soybean meal | 3.23 | 6.98 | — | — | — |
| Animal fat | .12 | .17 | .11 | .11 | .10 |
| Limestone | 1.32 | 1.34 | 1.45 | 1.53 | 1.50 |
| Dicalcium phosphate | .15 | .07 | .20 | .04 | — |
| Potassium chloride | .25 | .05 | .57 | .54 | .47 |
| Salt | .30 | .30 | .30 | .30 | .30 |
| Urea | .54 | — | .54 | — | — |
| Ammonium sulfate | — | — | — | .02 | .14 |
| Trace mineral premix[b] | .05 | .05 | .05 | .05 | .05 |
| Vitamin premix[c] | .01 | .01 | .01 | .01 | .01 |
| Monensin premix[d] | .02 | .02 | .02 | .02 | .02 |
| Tylosin premix[e] | .01 | .01 | .01 | .01 | .01 |
| Nutrient composition[f] | | | | | |
| Starch | 59.0 | 57.3 | 60.1 | 56.5 | 41.6 |
| Crude protein | 12.0 | 12.0 | 11.7 | 11.4 | 15.5 |
| Metabolizable protein[g] | 9.3 | 9.5 | 9.1 | 8.9 | 12.2 |
| NDF | 14.9 | 15.1 | 16.5 | 18.0 | 23.5 |
| Fat | 3.7 | 3.6 | 4.4 | 5.0 | 7.4 |
| Ash | 2.7 | 2.9 | 2.0 | 2.2 | 2.8 |
| Dry matter | 79.6 | 79.8 | 68.8 | 57.0 | 34.7[h] |

[a]Fed as the source of drinking water.
[b]10% Mg, 6% Zn, 4.5% Fe, 2% Mn, .5% Cu, .3% I, and .05% Co.
[c]15,000 IU of vitamin A, 3,000 IU of vitamin D, and 3.75 IU of vitamin E/g of premix.
[d]132 g of Monensin/kg of premix.
[e]88 g of Tylosin/kg of premix.
[f]Based on measured values. DM basis.
[g]Burroughs et al. (1974).
[h]Mixed diet (excluding thin stillage) DM = 59.0%.

In the distillation process, corn was ground, slurried with water, and cooked to gelatinize the starch. An amylase enzyme was added to convert starch to glucose. The resulting mash was inoculated with yeast and allowed to ferment, forming ethanol and carbon dioxide. The fermented mash was screened and pressed, separating the solids (wet distillers grains) and liquid. The liquid fraction was distilled, removing alcohol and forming the byproduct thin stillage. For each distillation, the byproducts were weighed, sampled, and measured for DM content (AOAC, 1975). The ratio of wet distillers grains:thin stillage production (DM basis) was computed monthly, and this ratio of byproducts was maintained in the diets. Samples were composited weekly and analyzed for Kjeldahl N (AOAC, 1975). Ingredient composites (as-is basis) were analyzed for starch (Herrera-Saldana and Huber, 1989), NDF (Robertson and Van Soest, 1977), fat (chloroform-methanol extraction; Moore et al., 1986), and ash (AOAC, 1975). Alcohol content of wet distillers grains and thin stillage was determined by gas chromatography (Hewlett-Packard, Avondale, PA) using a 2-m × 4-mm i.d. column packed with SP1200 (Supelco, Bellefonte, PA). Temperature of the column was 100°C and flow rate was 80 mL of N/min. Ethyl alcohol (95%) was used as an external standard (102% measured recovery).

*Yearling Finishing Trial.* One finishing trial (replicated over 2 yr) was conducted, beginning in May of 1990 and 1991. Eighty mixed crossbred yearling steers were used in each year (Year 1, mean BW = 317 ± 3 kg; Year 2, mean BW = 340 ± 3 kg) to evaluate the feeding value of wet distillers byproducts (wet distillers grains and thin stillage). Steers were allotted randomly to eight pens (10 steers/pen; two pens/treatment/year). Treatments (Table 1) consisted of a control and 5.2, 12.6, and 40.0% (of diet DM) of wet distillers byproducts (**WDB**). Diets were formulated (DM basis) to contain a minimum of 12% CP, .7% Ca, .35% P, and .7% K and contained 27 and 11 mg/kg of monensin and tylosin, respectively. Supplemental protein for the control diet was a 50:50 combination

Table 2. Corn and wet distillers byproduct composition, percentage of DM[a]

| Nutrient | Corn | Wet grains | Thin stillage | WG:TS[b] |
|---|---|---|---|---|
| | % | | | |
| Starch | 70.3 | 9.0 | 22.0 | 13.9 |
| Crude protein | 10.1 | 25.0 | 16.8 | 21.9 |
| NDF | 10.9 | 39.4 | 11.7 | 29.1 |
| Fat | 3.8 | 13.7 | 8.1 | 11.6 |
| Ash | 1.4 | 1.4 | 5.9 | 3.1 |
| Ethanol | — | 10.7 | 12.2 | 11.3 |
| Dry matter[c] | 89.8 | 31.4 | 5.0 | 21.5 |

[a]Average of yearling and calf trials.
[b]WG:TS = 1.68 wet grains:1 thin stillage (production ratio), DM basis.
[c]Includes ethanol.

(CP basis) of soybean meal and urea. The low level (5.2%) of WDB replaced the same amount of CP supplied by soybean meal in the control diet. The medium level (12.6%) of WDB replaced the same amount of CP supplied by soybean meal and urea in the control diet. The high level (40.0%) of WDB replaced all the soybean meal and urea CP, and a portion of the corn. Thus, the 40.0% WDB diet was designed to use WDB as a source of both protein and energy. The proportion of wet distillers grains:thin stillage was constant among levels and was based on the ratio of these two byproducts produced by the plant. Wet distillers grains were mixed in all diets. Because the moisture content of the thin stillage (95.5% moisture) was high, thin stillage was mixed in the 5.2 and 12.6% WDB diets and offered as the source of drinking water in the 40% WDB diet. When steers had consumed their allotted amount of thin stillage, water was available for ad libitum consumption.

Steers were adapted to the final diets during 21 d using four adaptation diets containing 45 (3 d), 35 (4 d), 25 (7 d), and 15% forage (7 d; DM basis). Forage was a mixture of corn silage and alfalfa hay with corn silage assigned an arbitrary value of 50% forage. Cattle were implanted with Compudose (Elanco Products, Indianapolis, IN), offered feed once daily for ad libitum intake, and housed in an open-front confinement barn (14.6 $m^2$/animal) with a gutter-flush system. Crude protein, starch, NDF, and fat intakes were calculated using values determined in our laboratory (Table 2). Metabolizable protein (**MP**) intakes were estimated using the system described by Burroughs et al. (1974) with one modification: 15 g of bacterial protein was not subtracted from fecal metabolic protein formation. This factor is included as a requirement in the MP requirement equation of the NRC (1985), with which MP intake was compared in these trials. Energy was calculated to be adequate for microbial growth; therefore, MP was determined as digestible escape protein (escape protein × .9) + digestible true bacterial protein (degradable protein × .8 × .8). Escape protein values for corn, corn silage, soybean meal, alfalfa hay, and wet distillers grains were 65.7, 23.2, 52.3 (Sindt et al., 1993), 28 (NRC, 1985), and 47% (Firkins et al., 1984), respectively. The $NE_g$ of each diet was calculated from cattle performance for each pen of steers. The net energy required for gain ($NE_gR$) was calculated by the equation $NE_gR = .0557\ W^{.75}\ (ADG^{1.097})$, where $NE_gR$ is the net energy required for daily weight gain (ADG) and W is the mean body weight (NRC, 1984). Maintenance net energy required ($NE_mR$) was calculated by the equation $NE_mR = .077\ W^{.75}$ (NRC, 1984). The NE content of the diet for gain and maintenance was assumed to fit the relationship: $NE_g = .877\ NE_m - .41$ (derived from NRC, 1984; Zinn, 1989). By the process of iteration, the $NE_g$ and $NE_m$ contents of the diets were calculated to fit the equation: $DMI = (NE_gR/NE_g) + (NE_mR/NE_m)$. The energy content of WDB was calculated by substitution, assuming basal ingredients possessed the same energy value (NRC, 1984) across all diets. Initial weights were based on the mean of two consecutive weights taken before feeding. Interim weights were based on one weight taken before feeding. Steers were fed for 134 and 112 d in 1990 and 1991, respectively. To minimize variation in gut fill, hot carcass weight adjusted for 62% dressing percentage was used to calculate final weight. Hot carcass weight and liver abscess score were recorded at slaughter. Livers were scored by a modification of the Elanco Products Company (1974) procedure using the following system: 0 = healthy liver; 1 = one to four small abscesses; 2 = one to four medium abscesses; 3 = one or more large abscesses; and 4 = adherence of abscess to diaphragm or digestive tract. Fat thickness, quality grade, and yield grade were recorded after the carcasses were chilled for 48 h.

Finishing performance, carcass traits, and nutrient intakes were analyzed as a randomized complete design according to the GLM procedure of SAS (1985). Pen was used as the experimental unit. Model effects included year, replication, and treatment. Treatment means were tested for byproduct level × year interactions, and linear and quadratic contrasts were tested among WDB levels.

*Calf Finishing Trial.* One finishing trial (replicated over 2 yr) was conducted, beginning in November of 1990 and 1991. Eighty mixed crossbred steer calves were used each year (Year 1, mean BW = 274 ± 1 kg; Year 2, mean BW = 279 ± 1 kg). Experimental treatments and procedures for the calves were the same as those for the yearlings, with the following exceptions. The control supplement contained soybean meal as the protein source, as opposed to 50% soybean meal:50% urea for the yearlings (Table 1). Upon arrival at the feedlot, calves were vaccinated and allowed to adjust to the feedlot for 30 d. Calves were fed for 195 and 181 d in 1990 and 1991, respectively. Adaptation to the final diets, implant program, feeding, weighing, carcass measurements, estimation of $NE_g$, and statistical analyses were performed as in the yearling trials.

*Thin Stillage Bypass Trial.* Six ruminally fistulated yearling steers (mean BW = 580 ± 8 kg) were used to estimate the percentage of thin stillage, consumed by drinking, that bypasses ruminal fermentation. Surgical procedures and postsurgical care were the same as those outlined by Stock et al. (1991), and all procedures had been reviewed and accepted by the University of Nebraska Institutional Animal Care Program. Steers were housed in 3-m × 3-m individual pens in a 25°C temperature-controlled room. Steers were fed the yearling control diet (Table 1) once daily in ad libitum amounts for 2 wk before the experiment. Thin stillage (DM = 5.4%) was marked with Co-EDTA (800 mg of Co-EDTA/13.5 L of thin stillage) and offered to each steer for 15 min. After 15 min, the rumen was emptied. Ruminal evacuation was completed within 25 min. Ruminal contents were weighed, mixed, subsampled, and replaced. Refused stillage was weighed and sampled. Three steers were evacuated per day for 2 d. One week later, the procedure was repeated. Thin stillage and ruminal contents of each steer were analyzed for Co by atomic absorption (Varion Techtron Pty. Limited, Mulgrave, Victoria, Australia). The percentage of thin stillage that bypassed the rumen was calculated by the following equation: percentage of thin stillage bypass = 100 − [(milligrams of Co measured in the rumen/milligram of Co consumed) × 100].

## Results

*Byproduct Production.* Approximately 990 kg (DM basis) of corn was fermented per batch (every 2 d) and 35% of the corn DM was recovered as wet distillers byproducts. In general, distillation removed the cornstarch (Table 2), which concentrated the remaining nutrients. Crude protein content of thin stillage produced in our plant (19.0%) was lower than the NRC (1984) value (29.7%). The mean production ratios (DM basis) of wet distillers byproducts (wet grains:thin stillage) during the yearling and calf trials were 1.65:1 and 1.70:1, respectively, compared with the average feeding ratios of 1.67:1 and 1.81:1 for the yearling and calf trials, respectively (Table 3). Dry matter content of the byproducts was variable (wet grains mean CV = 9.53%; thin stillage mean CV = 21.22%; Table 3). This variability required weekly adjustments of byproduct DM content to ensure the proper amount in the diet. Thin stillage contained 12.2% and wet distillers grains contained 10.7% alcohol (DM basis), which would be volatized when drying to determine DM. Adjusted feed efficiency values are reported (Tables 4 and 6) to account for ethanol consumption.

*Yearling Finishing Trial.* No interactions ($P > .1$) between years in yearling performance were detected among WDB levels; therefore, the data were pooled across years (Table 4). During the first 45 d, as the level of WDB increased from 0 to 40% of the diet (DM basis), DMI was affected both linearly ($P < .01$) and quadratically ($P = .04$). Yearlings fed 5.2 and 12.6% WDB consumed more DM than yearlings fed the control (quadratic, $P = .04$) or 40% WDB diets. Daily gain and efficiency were not significantly altered by WDB level. During the entire trial, as the level of WDB increased, cattle consumed less DM (linear, $P < .01$) than the controls. Daily gain increased (linear, $P = .07$) and reached a plateau (quadratic, $P = .08$) as the level of WDB increased. Yearlings fed increasing levels of WDB were more efficient (linear, $P < .01$; quadratic, $P = .05$) than the controls. Estimated diet $NE_g$ content reflected cattle performance and increased (linear, $P < .01$; quadratic, $P = .06$) from 1.21 Mcal/kg for the control diet to 1.48 Mcal/kg for the 40.0% WDB diet. Fat thickness, liver abscess score, and quality grade were not affected by WDB level.

Metabolizable protein intake (Figure 1) during the first 45 d was higher than the estimated requirement (.7 kg/d; NRC, 1985) for yearlings fed 0, 5.2, or 12.6% WDB, whereas yearlings fed 40% WDB consumed 77% more MP than was required for optimal growth. Throughout the entire feeding period, yearlings fed 5.2 and 12.6% WDB consumed less MP than the controls, but all steers consumed ≥ 44% more MP than was required for optimal growth (.68 kg/d; NRC, 1985). Starch intake declined as WDB increased, whereas NDF and fat intake increased (Table 5).

*Calf Finishing Trial.* No interactions ($P > .10$) were detected among WDB levels and years; therefore, data were pooled across years. Calves and yearlings responded similarly to level of WDB. During the first 26 d, as level of WDB increased from 0 to 40% of the diet (DM basis), DMI declined (linear, $P = .05$; Table 6). During the entire trial, as observed with the yearlings, calves fed increasing levels of WDB consumed less DM (linear, $P < .01$), gained faster (linear, $P < .01$), and were more efficient (linear, $P < .01$) than the control calves. Estimated $NE_g$ content increased (linear, $P < .01$) from 1.34 Mcal/kg for the control diet to 1.53 Mcal/kg for the 40.0% WDB diet.

Table 3. Wet distillers byproduct production and DM content during yearling and calf trials

| Item | df | Wet grains | SD | Thin stillage | SD |
|---|---|---|---|---|---|
| Production, kg DM/d | | | | | |
| Yearlings | 121 | 217 | 36 | 132 | 16 |
| Calves | 186 | 207 | 54 | 125 | 10 |
| DM, % | | | | | |
| Yearlings | 121 | 28.53 | 2.67 | 4.52 | 1.05 |
| Calves | 186 | 27.44 | 2.66 | 4.27 | .82 |

Fat thickness and liver abscess score were not affected by WDB level. However, calves fed increasing levels of WDB graded higher (linear, $P < .01$) than the control calves.

Metabolizable protein intake (Figure 2) during the first 26 d was similar to the estimated requirement (.73 kg/d; NRC, 1985) for calves fed 0, 5.2, or 12.6% WDB, whereas calves fed 40% WDB consumed 27% more MP than required. Throughout the entire trial, calves consumed ≥ 37% more MP than required (.7 kg/d; NRC, 1985), and only cattle fed 40% WDB consumed more MP than the control. Calves fed WDB consumed less starch but more NDF and fat than the control calves (Table 5).

*Thin Stillage Bypass Trial.* Steers consumed 11.8 ± 1.3 kg (mean ± SD) of the yearling control diet DM/d, which was similar to the yearling feedlot intakes (Table 4). Within 15 min, steers consumed 9.5 ± 2.6 L (mean ± SD) of the 13.5 L of thin stillage offered. Based on the amount of Co measured in the rumen, 52.7 ± 10.9% (mean ± SD) of the thin stillage did not mix with ruminal contents, but bypassed the rumen. The variation of this estimate was high (CV = 21%); however, it seems that not all of the thin stillage that was drunk entered the rumen and mixed with the ruminal contents.

## Discussion

Accounting for ethanol intake, yearlings were 5, 10, and 20% more efficient, whereas calves were 2, 6, and 14% more efficient than the control cattle when fed 5.2, 12.6, and 40.0% WDB, respectively. Similar to our results, Farlin (1981) reported increased ADG and decreased DMI, resulting in improved feed efficiency (12 and 11%, respectively), when wet distillers grains replaced 50 or 75% of the corn (42.50 or 63.75% of diet DM, respectively) in an 85% dry-rolled corn diet. However, performance was not affected when 21.25% of the diet (DM basis) consisted of wet distillers grains. In agreement with our data, Firkins et al. (1985) reported a linear increase in ADG ($P < .08$); however, DMI was not affected when 25 or 50% (of diet DM) wet distillers grains was fed, compared with an 80% corn-control diet. Feed efficiency was improved (linear, $P < .07$) by 1 and 11% by the addition of 25 and 50% wet distillers grains.

Protein content of the byproducts was lower than predicted, resulting in less CP and MP content in the 5.2 and 12.6% WDB diets than the control (Table 1).

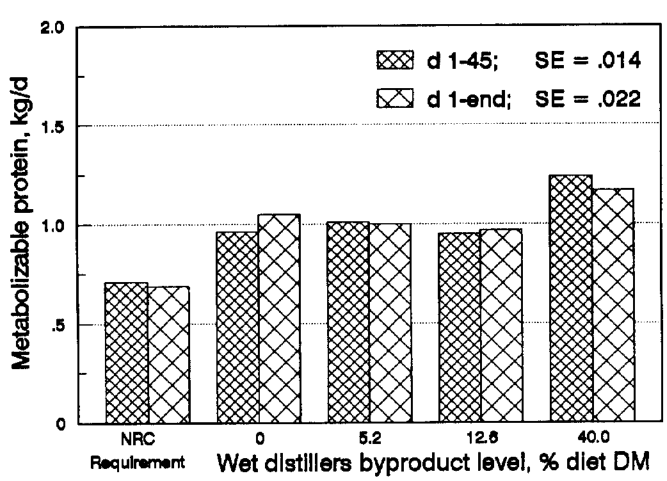


Figure 1. Metabolizable protein intake vs requirement for yearlings during the first 45 d and the entire feeding period.

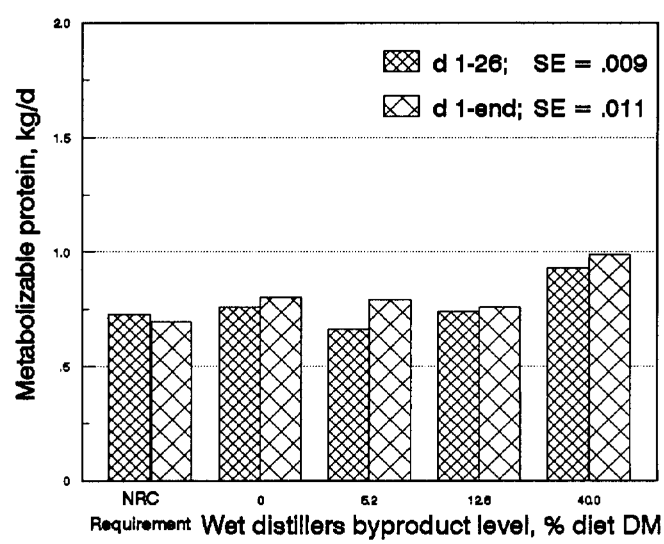


Figure 2. Metabolizable protein intake vs requirement for calves during the first 26 d and the entire feeding period.

Table 4. Effect of level of wet distillers byproduct on finishing performance, diet net energy for gain ($NE_g$), and carcass characteristics of yearlings

| | Byproduct level, % of diet DM[a] | | | | | P-value | |
|---|---|---|---|---|---|---|---|
| Item | 0 | 5.2 | 12.6 | 40.0 | SE | Linear | Quadratic |
| Daily feed, kg | | | | | | | |
| d 1–45 | 10.57 | 11.39 | 10.80 | 10.39 | .13 | < .01 | .04 |
| d 1–end | 11.46 | 11.20 | 10.93 | 9.68 | .22 | < .01 | .91 |
| Ethanol intake, kg | | | | | | | |
| d 1–45 | 0 | .07 | .15 | .46 | .01 | < .01 | .75 |
| d 1–end | 0 | .06 | .15 | .43 | .01 | < .01 | .09 |
| Daily gain, kg | | | | | | | |
| d 1–45 | 2.03 | 2.14 | 2.08 | 2.03 | .07 | .60 | .55 |
| d 1–end | 1.65 | 1.71 | 1.76 | 1.76 | .03 | .07 | .08 |
| Gain/feed | | | | | | | |
| d 1–45 | .192 | .188 | .192 | .196 | .008 | .61 | .86 |
| d 1–end | .144 | .152 | .160 | .181 | .002 | < .01 | .05 |
| Adjusted gain/feed[b] | | | | | | | |
| d 1–45 | .192 | .187 | .190 | .188 | .008 | .83 | .86 |
| d 1–end | .144 | .151 | .158 | .173 | .002 | < .01 | .04 |
| Diet $NE_g$, Mcal/kg[c] | 1.21 | 1.28 | 1.34 | 1.48 | .02 | < .01 | .06 |
| Hot carcass wt, kg | 329 | 335 | 338 | 338 | 2 | .07 | .08 |
| Fat thickness, cm | 1.2 | 1.5 | 1.4 | 1.3 | .1 | .48 | .11 |
| Liver abscess score[d] | .13 | .13 | .03 | .03 | .09 | .43 | .60 |
| Quality grade[e] | 18.9 | 19.2 | 18.9 | 18.7 | .2 | .28 | .68 |

[a]Wet grains:thin stillage = 1.67:1, DM basis.
[b]Accounts for ethanol consumption.
[c]Based on cattle performance (NRC, 1984).
[d]See text for description.
[e]High Select = 18; low Choice = 19.

In addition, cattle fed WDB consumed less DM (Tables 4 and 6). As a result, calves and yearlings fed intermediate (5.2 and 12.6%) levels of wet distillers byproducts received less MP than the controls did (Table 5). Over the entire trial, MP intakes were above the calculated requirement for all treatments (Figures 1 and 2). Improved ADG and feed efficiency of calves fed 5.2% or 12.6% WDB could not have been

Table 5. Effect of level of wet distillers byproduct on nutrient intake of yearlings

| | Byproduct level, % of diet DM[a] | | | | | P-value | |
|---|---|---|---|---|---|---|---|
| Nutrient intake, kg/d | 0 | 5.2 | 12.6 | 40.0 | SE | Linear | Quadratic |
| Crude protein | | | | | | | |
| Yearlings | 1.38 | 1.31 | 1.24 | 1.48 | .03 | < .01 | < .01 |
| Calves | 1.01 | 1.02 | .96 | 1.23 | .01 | < .01 | < .01 |
| Metabolizable protein[b] | | | | | | | |
| Yearlings | 1.05 | 1.01 | .97 | 1.17 | .02 | < .01 | < .01 |
| Calves | .80 | .79 | .76 | .99 | .01 | < .01 | < .01 |
| Starch | | | | | | | |
| Yearlings | 6.52 | 6.50 | 5.95 | 3.85 | .12 | < .01 | .07 |
| Calves | 4.74 | 5.16 | 4.67 | 3.22 | .05 | < .01 | < .01 |
| NDF | | | | | | | |
| Yearlings | 1.89 | 2.02 | 2.14 | 2.41 | .04 | < .01 | .13 |
| Calves | 1.36 | 1.53 | 1.61 | 1.94 | .02 | < .01 | .02 |
| Fat | | | | | | | |
| Yearlings | .41 | .48 | .55 | .71 | .01 | < .01 | .01 |
| Calves | .30 | .38 | .42 | .59 | .01 | < .01 | .01 |

[a]Wet grains:thin stillage = 1.67:1, DM basis.
[b]Calculated using the system described by Burroughs et al. (1974).

Table 6. Effect of level of wet distillers byproduct on finishing performance, diet net energy for gain ($NE_g$), and carcass characteristics of calves

| Item | Byproduct level, % of diet DM[a] | | | | SE | P-value | |
|---|---|---|---|---|---|---|---|
| | 0 | 5.2 | 12.6 | 40.0 | | Linear | Quadratic |
| Daily feed, kg | | | | | | | |
| d 1–26 | 8.26 | 8.25 | 8.46 | 7.80 | .09 | .05 | .16 |
| d 1–end | 8.42 | 8.74 | 8.44 | 7.91 | .13 | < .01 | .21 |
| Ethanol intake, kg | | | | | | | |
| d 1–26 | 0 | .05 | .12 | .35 | .01 | < .01 | .46 |
| d 1–end | 0 | .05 | .12 | .36 | .01 | < .01 | .30 |
| Daily gain, kg | | | | | | | |
| d 1–26 | 1.86 | 1.66 | 1.88 | 1.88 | .08 | .50 | .91 |
| d 1–end | 1.30 | 1.39 | 1.40 | 1.46 | .03 | < .01 | .13 |
| Gain/feed | | | | | | | |
| d 1–26 | .224 | .204 | .222 | .242 | .011 | .15 | .58 |
| d 1–end | .155 | .159 | .166 | .185 | .003 | < .01 | .58 |
| Adjusted gain/feed[b] | | | | | | | |
| d 1–26 | .224 | .203 | .219 | .232 | .010 | .36 | .59 |
| d 1–end | .155 | .158 | .164 | .177 | .003 | < .01 | .54 |
| Diet $NE_g$, Mcal/kg[c] | 1.34 | 1.36 | 1.42 | 1.53 | .03 | < .01 | .51 |
| Hot carcass wt, kg | 324 | 333 | 336 | 342 | 3 | .01 | .15 |
| Fat thickness, cm | 1.3 | 1.4 | 1.4 | 1.4 | .1 | .21 | .27 |
| Liver abscess score[d] | .25 | .03 | .00 | .00 | .13 | .34 | .27 |
| Quality grade[e] | 18.9 | 19.3 | 19.3 | 19.8 | .2 | < .01 | .51 |

[a]Wet grains:thin stillage = 1.81:1, DM basis.
[b]Accounts for ethanol consumption.
[c]Based on cattle performance (NRC, 1984).
[d]See text for description.
[e]High Select = 18; low Choice = 19.

due to CP or MP intake because protein intake was less than the control and well above NRC (1985) requirement. Therefore, improvements in yearling and calf performance at each level of wet distillers byproducts was attributed to increased energy utilization.

Based on cattle performance, the control diets were calculated to contain 88% (yearling) and 96% (calf) as much energy as calculated by tabular values (NRC, 1984). The $NE_g$ content of wet WDB was calculated by substitution for corn and molasses, assuming that individual basal ingredients possessed the same energy value across each diet. Wet distillers byproducts contributed 80, 62, and 47% more energy than corn when fed to yearlings and 17, 33, and 29% more energy than corn when fed to calves at 5.2, 12.6, and 40.0%, respectively. Wet distillers byproducts contained an average of 2.53 Mcal of $NE_g$/kg (1.6 times more energy than corn) for yearlings and 1.96 Mcal of $NE_g$/kg (1.3 times more energy than corn) for calves.

A combination of factors likely contributed to the high energy value of WDB. First, the byproducts contained over three times more fat (corn oil) than does corn (Table 2). Fat contains three times more $NE_g$ than does corn (Zinn, 1989), but fat content could only account for WDB to contain 9% more energy than corn. Second, ethanol is rapidly absorbed from the rumen (Tsuda, 1957; Emery et al., 1959) and would be metabolized to acetate and utilized for energy or lipogenesis. Ethanol contains 7.1 Mcal/kg of GE, compared with 4.2 Mcal/kg in starch (Blaxter, 1989). Third, cattle fed WDB consumed less starch and more corn fiber than did the controls (Table 3). Farlin (1981) and Firkins et al. (1985) suggested that increased feed efficiency when wet distillers grains was fed may have been due in part to a reduction in subacute acidosis. High starch intake leads to increased production of ruminal organic acids that may result in subacute acidosis (Burrin and Britton, 1986). Subacute acidosis reduces gain and efficiency (Stock et al., 1990). Acute acidosis reduces nutrient absorption (Huntington and Britton, 1979); however, the effects of chronic subacute acidosis on nutrient absorption have not been studied. Conversely, corn fiber has been characterized as highly digestible (DeHaan, 1983). Therefore, substituting cornstarch with highly digestible corn fiber may not have reduced energy utilization in these diets. The greater potential for yearlings to experience acidosis may have contributed to the different energy values, relative to corn (yearlings, average relative value = 163%; calves, average relative value = 126%). Yearlings fed the control diet consumed 6.5 kg of starch/d, whereas calves consumed 4.7 kg of starch/d. Relieving subacute acidosis has usually been associated with an increase in feed intake (Tremere, 1968; Fulton et al., 1979). However, cattle also attempt to eat to a constant energy level (Baile and Della-Fera, 1981; Miner, 1992). Because WDB contained more energy than corn, DMI was not increased (Tables 4 and 6). Finally, the use of bypass protein as an energy source may have reduced metabolic losses (i.e., methane and heat) associated with microbial fermentation (Blaxter, 1962; Ørskov et al., 1969; Black and Tribe, 1973).

Wet distillers byproducts contain live and dead yeast cells. A number of investigators have examined the effects of yeast cultures on ruminal VFA and ammonia concentrations when animals are fed roughage diets. The use of live yeast culture has shown variable effects on ruminal fermentation; however, increases in concentration of cellulolytic bacteria in the rumen have been more consistent (Wiedmeier et al., 1987; Dawson et al., 1990). However, results of yeast cultures with roughage diets may not be similar to results with finishing diets due to differences in grain content, species of bacteria, ruminal pH, feed intake, etc. In addition, the number of live yeast cells was not determined in our studies.

Others have determined that a portion of liquid ingested by drinking bypasses the rumen. Woodford et al. (1984) reported that 18% of drinking water ingested by lactating dairy cows 4.5 h after feeding bypassed the rumen. In beef cattle, 40 to 80% of ingested water has been reported to bypass the rumen (Garza and Owens, 1989, 1990; Garza et al., 1990; Zorilla-Rios et al., 1990).

Hanke et al. (1983) evaluated thin stillage as a replacement for drinking water in three feedlot trials (300 steers). Steers fed thin stillage gained 5.7% faster, consumed 5.8% less DM, and required 11% less DM/kg of gain than steers receiving water. The authors suggested that enhanced performance may have been due to high levels of certain trace elements in thin stillage or to changes in ruminal digestion of carbohydrate and(or) protein (Hanke et al., 1983). Our data indicate that a portion of the thin stillage may have bypassed the rumen. In our trial, yearling finishing steers fed 40.0% WDB drank 34.5 L/d of thin stillage. Assuming that 50% of the thin stillage bypassed the rumen, .8 kg of DM from thin stillage entered the small intestine to be enzymatically digested. Microbial fermentation of starch and protein results in lost energy efficiency (Blaxter, 1962; Ørskov et al., 1969; Black and Tribe, 1973) due to the heat of fermentation. Rust et al. (1990) reported that decanted thin stillage (7.56% DM) provided 4.68 Mcal/kg of ME when replacing drinking water of steers fed a 90% concentrate diet. Converting ME to NE (Garrett, 1980), decanted thin stillage provided 2.4 Mcal of $NE_g$/kg when replacing water. Our data indicated that WDB, replacing 40% of the diet DM, with the thin stillage portion supplied as drinking water, contained 2.3 Mcal of $NE_g$/kg for yearlings and 2.0 Mcal/kg for calves.

## Implications

Using wet distillers byproducts in finishing diets as both a protein and energy source enables rapid and concentrated dispersion of the wet product. When fed (up to 40% diet DM) to finishing cattle, wet distillers byproducts contained 2.53 Mcal of net energy for gain/kg (63% more than corn) for yearlings and 1.96 Mcal of net energy for gain/kg (26% more than corn) for calves. Thus, if handling problems can be managed, wet distillers byproducts can enhance the efficiency of beef production.

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