Western Beef Resource Committee

Cattle Producer's Library

Nutrition Section CL332

# Barley for Beef Cattle

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Barley is an important energy source for beef cattle. In a review of 605 feeding trials published in North American journals and experiment station bulletins since 1974, barley was shown to have higher average net energy (NE) values than did corn (1.12 vs. 1.07 Mcal/lb $NE_m$; 0.79 vs. 0.75 Mcal/lb $NE_g$) (Owens et al. 1997).

Net energy is the amount of energy in feed that is available to cattle for maintenance ($NE_m$) and gain ($NE_g$) functions. However, all barley is not the same. Barley variety, type (malt vs. feed, hulled vs. hulless, 2-row vs. 6-row), and growing environment can affect nutrient composition (Bowman et al. 2001; Ovenell-Roy et al. 1998), rate of digestion (Boss and Bowman 1996b; Surber and Bowman 1998), and feedlot performance in cattle (Boss and Bowman 1996a; Ovenell-Roy et al. 1998).

One of the challenges in balancing diets for beef cattle using barley is its wide variation in nutrient content. In addition, until recently there has not been a well-defined set of criteria for determining barley feed quality. This guide outlines factors that can affect cattle performance when fed barley and identifies characteristics that are important in choosing high quality feed barley for cattle.

## Nutrient Content

Table 1 presents the average nutrient content of barley as reported by several sources. Barley samples analyzed by Montana State University demonstrate that the nutrient content of barley can vary tremendously. Although the average values for crude protein (CP), acid detergent fiber (ADF), and starch are fairly consistent among the four sources reported, the range between individual barley samples can be quite large.

In the samples reported by Montana State University, CP content ranged from 7.2 to 17.5 percent, ADF content ranged from 1.9 to 10.0 percent, starch content ranged from 38.3 to 76.0 percent, and nylon bag digestibility ranged from 12.6 to 71.0 percent. Particle size after dry rolling, an indication of barley processing characteristics, was also quite variable ranging from 0.04 to 0.11 inch.

## Growing Environment

Feed quality characteristics in the same barley population have been shown to vary from year to year, between dryland and irrigated environments, and between different growing locations. Montana State University research found that growing year affected all

**Table 1. Nutrient composition of barley grain (dry matter basis).**

| | | NRC (1996) | | Froseth and Miller | Montana State University | | | |
|---|---|---|---|---|---|---|---|---|
| Nutrient | NRC (1971) | No. samples | Avg. | (1992) | No. samples | Min. | Max. | Avg. |
| Dry matter, % | 89.0 | 1,743 | 88.1 | 92.3 | 1,407 | 88.1 | 94.8 | 92.3 |
| Crude protein, % | 13.0 | 1,884 | 13.2 | 12.5 | 1,246 | 7.2 | 17.5 | 13.2 |
| Ether extract, % | 1.9 | 8 | 2.2 | 2.2 | — | — | — | — |
| Ash, % | 3.4 | 1,153 | 2.4 | 2.7 | — | — | — | — |
| Acid detergent fiber, % | — | 1,399 | 5.8 | 7.1 | 1,046 | 1.9 | 10.0 | 5.0 |
| Starch, % | 60.4 | — | — | 55.6 | 1,343 | 38.3 | 76.0 | 54.2 |
| DMD, %[a] | — | — | — | — | 1,433 | 12.6 | 71.0 | 42.7 |
| Particle size, inches[b] | — | — | — | — | 981 | 0.038 | 0.109 | 0.045 |

[a]Nylon bag dry matter digestibility after 3 hours incubation in the rumen.
[b]Particle size measured after dry rolling.

**Table 2. Nutrient content of 10 barley lines grown at seven locations in Montana and under dryland or irrigated conditions.**

| | ADF | Starch | DMD[y] | Particle size[z] |
|---|---|---|---|---|
| | (%) | (%) | (%) | (inches) |
| **Location** | | | | |
| Bozeman | 4.56[b] | 54.56[b] | 34.49[b] | 0.050[c] |
| Conrad | 4.53[ab] | 56.92[cd] | 41.02[c] | 0.046[a] |
| Havre | 4.71[b] | 56.14[c] | 22.99[a] | 0.051[cd] |
| Huntley | 4.20[a] | 58.05[d] | 34.23[b] | 0.052[de] |
| Kalispell | 4.66[b] | 52.52[a] | 35.93[b] | 0.048[b] |
| Moccasin | 4.43[ab] | 60.33[e] | 42.60[c] | 0.050[c] |
| Sidney | 5.32[c] | 54.81[b] | 34.64[b] | 0.053[e] |
| **Environment** | | | | |
| Dryland | 4.46[a] | 54.95[a] | 34.80 | 0.051[b] |
| Irrigated | 4.81[b] | 57.43[b] | 35.45 | 0.048[a] |

[a, b, c, d, e] Means in a column without a superscript in common are different ($P < 0.01$).

[y]Nylon bag dry matter digestibility after 3 hours incubation in the rumen.

[z]Particle size measured after dry rolling.

feed quality traits of 62 barley lines (Surber et al. 1999). Average starch content of these 62 barley lines grown in three years varied from 52.8 to 56.9 percent.

Growing location affected feed quality characteristics of 10 barley lines grown at seven locations in Montana (Table 2). Among the seven growing locations, ADF content ranged from 4.20 to 5.32 percent, starch content ranged from 52.52 to 60.33 percent, digestibility ranged from 22.99 to 42.60 percent, and particle size after dry rolling ranged from 0.046 to 0.053 inch. In addition, dryland and irrigated environments affected feed quality of these same barley lines (Table 2). In general, dryland environments result in higher CP content, but lower ADF and starch content, compared with irrigated environments.

## Test Weight

Producers often use test weight as an indicator of barley feed quality, but research has not found a strong relationship. Montana State University researchers compared lightweight (42 lb/bu) and heavy weight (52 lb/bu) Busch 1202 barley in backgrounding (60% barley) and finishing (85% barley) diets for beef steers, and found no difference in intake, gain, or efficiency. Fiber and beta-glucan content have been shown to be important determinants of barley energy value for non-ruminants (Beames et al. 1996; Fairbairn et al. 1999). However, a University of Idaho researcher reported that barley test weight was not a good indicator of feed quality, especially in the higher test weight ranges (Hunt 1996).

## Malt vs. Feed Type Barley

Until recently, feed-type barley varieties have been selected based on agronomic characteristics, not actual feeding quality for animals (Molina-Cano et al. 1997). Malt-type barley, on the other hand, has been selected for the ability to be rapidly modified, a process where the cell walls and protein matrix in the starchy endosperm are degraded to expose the starch. The modification process is not unlike digestion in the animal, and therefore, it should not be surprising that malting barleys often have better nutritional value than feed barleys (Molina-Cano et al. 1997; Ullrich et al. 1981).

Several studies have found higher average daily gain when cattle were fed malting barley compared with feed barley. Researchers at Montana State University reported higher average daily gains by steers fed Harrington, a malt-type barley, compared with steers fed Medallion, a feed-type barley (Boss and Bowman 1996a). Two 112-day feedlot studies found higher average daily gains by steers fed Morex, a malt-type barley, compared with steers fed Baronesse, Lewis, or Steptoe, all feed-type barleys (Bowman et al. 1997).

Feed-type barleys are now beginning to be selected based on actual feeding quality. An example of a feed barley selected and released based on improved feed quality for beef cattle is “Valier,” recently released by the Montana Agricultural Experiment Station. Hopefully, this trend will continue, and feed barleys will be evaluated for feeding quality before their release.

## Hulled vs. Hulless Cultivars

Compared with hulled barley cultivars, hulless cultivars contain less fiber and more starch. Hulless barley cultivars have been shown to have higher digestibility and energy value for pigs than hulled cultivars (Beams et al. 1996). When 16 hulled and six hulless barley cultivars grown in Alberta were compared, the hulless cultivars had an average 5.5 percent greater ruminal digestibility (Lehman et al. 1995).

Montana State University researchers evaluated feed quality characteristics of barley in the USDA National Small Grains Collection and found hulless types had greater starch content and lower ADF content than hulled types (Bowman et al. 2001). It appears that due to the reduced fiber content and increased starch content, hulless barley would have better feed quality for beef cattle compared to hulled cultivars. Very few studies have addressed differences in feed quality for cattle between hulled and hulless barley cultivars.

University of California researchers reported higher starch and lower fiber contents for “Condor,” a hulless barley cultivar, compared with “Leduc,” a hulled cultivar (Zinn et al. 1996). Diet net energy value was 5.6 percent greater in feedlot steers fed Condor than in steers fed Leduc, although there was not a corresponding increase in average daily gain.

Montana State University researchers reported that feedlot steers fed the hulless cultivar "Merlin" had increased average daily gain compared to steers fed the hulled cultivar "Baronesse," but similar gain to steers fed the hulled cultivar "Chinook" (Bowman and Blake 1996). A limitation of hulless cultivars for ruminants might be the increased rate of digestion (Lehman et al. 1995) resulting in excessive ruminal acid accumulation.

Steers fed hulless "Condor" had a lower ruminal pH and an increased incidence of liver abscesses compared with steers fed hulled "Leduc" (Zinn et al. 1996). An increased incidence of metabolic disorders, such as bloat, acidosis, and laminitis, can also result from excessive acid production (Hunt 1996).

## 2-Rowed vs. 6-Rowed Cultivars

Grain of 2-row head types has been shown to elicit higher animal performance compared with grain of 6-row types when fed in high concentrate diets to steers (Boss and Bowman 1996a; Ovenell-Roy et al. 1998). The higher animal performance shown with 2-row barley cultivars might be due to the higher starch and lower fiber content found in 2-row types compared with 6-row types.

In the USDA National Small Grains Collection, 6-row barley types had greater ADF content and particle size after dry rolling, and lower starch content, ruminal DM digestibility, ruminal starch digestibility, and digestible starch content compared with 2-row head types (Bowman et al. 2001). When 2-row and 6-row barley cultivars that had been grown at three locations in Alberta, Canada, were evaluated, 6-row types had lower ruminal digestibility than 2-row types (Lehman et al. 1995).

## Barley Energy Content

Corn has often been reported to be the most profitable feed grain for finishing beef cattle, and frequently the statement is made that barley would be a more desirable feed grain if it could be made more similar to corn. However, when the effects of grain source on feedlot performance were evaluated in 605 feeding trials involving over 23,000 cattle, Oklahoma State University researchers concluded that cattle fed barley had comparable ADG to cattle fed corn (Owens et al. 1997). These authors commented, "Rates of gain for cattle fed barley were surprisingly high."

**Table 4. Performance by beef steers fed feedlot diets based on different barley varieties at Montana State University.**

| Variable | No. of observations | Min. | Max. | Avg. |
|---|---|---|---|---|
| Average daily gain, lb[a] | 1,080 | 2.38 | 3.85 | 3.19 |
| Barley $NE_m$, Mcal/lb | 54 | 0.84 | 1.28 | 1.07 |
| Barley $NE_g$, Mcal/lb | 54 | 0.55 | 0.94 | 0.75 |

[a]After approximately 140 days on feed, 85 percent barley, 6 percent roughage, 9 percent supplement.

According to the Owens et al. (1997) summary (Table 3), dry rolled barley had a 13 percent higher $NE_m$ content and a 16 percent higher $NE_g$ content, compared with dry rolled corn (1.13 vs. 1.00 Mcal/lb $NE_m$; 0.80 vs. 0.69 Mcal/lb $NE_g$). In addition, they found that although the energy values for corn and milo in their review were similar to the values predicted by the NRC (1996), the energy values for barley were actually 24 percent greater than the values stated by the NRC (0.93 Mcal/lb $NE_m$, 0.63 Mcal/lb $NE_g$). Research at Montana State University has given average $NE_m$ and $NE_g$ values for barley (Table 4) of 1.07 Mcal/lb $NE_m$ and 0.75 Mcal/lb $NE_g$. These values are slightly higher than values of 0.97 Mcal/lb $NE_m$ and 0.67 Mcal/lb $NE_g$ estimated for dry rolled barley by University of California researchers (Zinn 1993).

In addition, Montana State University research has demonstrated differences in animal performance between barley varieties (Table 4). The performance data presented in Table 4 include cattle fed 20 different barley genotypes, with ADG ranging from 2.38 to 3.85 lb/day, $NE_m$ ranging from 0.84 to 1.28 Mcal/lb, and $NE_g$ ranging from 0.55 to 0.94 Mcal/lb.

## Identifying High Quality Feed Barley

Recent research has identified barley grain characteristics that can be used to predict feed quality for beef cattle (Surber et al. 2000). These include high starch content, low acid detergent fiber content, low nylon bag digestibility, and large particle size after dry rolling.

Performance data used for these analyses were from 18 feedlot trials conducted in Montana and Idaho, during 1993 through 2000, including approximately 1,120 steers. Diets based on 21 barley genotypes were

**Table 3. Effects of processing barley and corn grain on beef cattle performance (adapted from Owens et al. 1997).**

| | Barley | | | Corn | | |
|---|---|---|---|---|---|---|
| | Whole | Dry roll | Steam roll | Whole | Dry roll | Steam roll |
| Average daily gain, lb | 3.04 | 3.20 | 2.93 | 3.20 | 3.20 | 3.15 |
| Dry matter intake, lb | 20.5 | 19.8 | 18.2 | 18.9 | 20.8 | 18.4 |
| Feed efficiency, lb gain/100 lb feed | 15.0 | 16.0 | 16.2 | 16.8 | 15.2 | 17.0 |
| $NE_m$, Mcal/lb | 0.88 | 1.13 | 1.12 | 1.10 | 1.00 | 1.18 |
| $NE_g$, Mcal/lb | 0.59 | 0.80 | 0.79 | 0.77 | 0.69 | 0.84 |

fed, including 14 barley cultivars (Baronesse, Busch 1202, Chinook, Colter, Gallatin, Gunhilde, Harrington, Lewis, Medallion, Merlin, Morex, Steptoe, and Valier) and seven experimental lines. Average steer body weight, dry matter intake, average daily gain, net energy for maintenance ($NE_m$) and net energy for gain ($NE_g$) requirements (NRC 1996) were used to estimate barley $NE_m$ and $NE_g$ content (Boss and Bowman 1996a).

Cattle fed barley with a slower rate of digestion performed better in the feedlot. In addition, barley with a slower rate of digestion had a higher energy value than barley with a faster rate of digestion and resulted in greater gain/feed. Barley with a high starch content and low fiber content had higher $NE_m$ and $NE_g$ and higher gain/feed. Selection for high starch content and low ADF content in barley is desirable. Barley with large particle size after dry rolling had higher gain/feed, therefore, selection for large particle size in barley is desirable. Low nylon bag digestibility, low ADF, high starch, and large particle size after dry rolling of barley grain appear to result in improved performance of cattle fed high barley diets.

## Processing of Barley

Processing of barley can substantially improve its energy value for beef cattle. Oklahoma State University researchers summarized 14 feedlot experiments with barley and reported improved ADG, feed efficiency, and energy content for dry rolled barley compared with whole barley (Table 3) (Owens et al. 1997).

Steam rolled barley had slightly improved feed efficiency compared with dry rolled, but ADG, $NE_m$, and $NE_g$ were not improved. University of California researchers (Zinn 1993) found higher $NE_m$ and $NE_g$ values for steam rolled barley compared with dry rolled (1.02 vs. 0.97 Mcal/lb $NE_m$; 0.71 vs. 0.67 Mcal/lb $NE_g$). However, two Canadian studies found no advantage of steam rolling compared with dry rolling for beef steers (Engstrom et al. 1992; Mathison et al. 1991).

In general, if barley is going to make up more than 50 percent of the diet, then dry roll processing is recommended. If barley is going to be used as a supplement to a forage-based diet, then processing should be evaluated based on cost. Based on energy values in Table 3, you would have to feed 28 percent more of whole barley to provide an equal amount of energy as dry rolled barley.

For example, 2 pounds of whole barley would contain: 2 pounds x 0.88 Mcal/lb $NE_m$ = 1.76 Mcal $NE_m$. Two pounds of dry rolled barley would contain: 2 pounds x 1.13 Mcal/lb $NE_m$ = 2.26 Mcal $NE_m$. To provide as many Mcal of $NE_m$ as are found in 2 pounds dry rolled barley, 2.26/1.76 = 1.28 times as much whole barley would need to be fed, or 2 pounds x 1.28 = 2.56 pounds whole barley. If the cost of processing is more than 28 percent of the cost of barley, then it would be more economical to feed 28 percent more whole barley than to pay for dry rolling. If the cost of processing is less than 28 percent of the cost of barley, then processing is more economical.

## Feeding Guidelines

When using barley in a feedlot or high-grain diet, it is important to slowly step cattle up to high grain levels. Cattle can be started on 0.5 percent body weight barley grain per day (3 pounds for a 600-pound steer) if they have all the hay they want to eat. The amount of grain should be increased gradually, with no more than 0.5 pound per animal per day increase. The incidence of digestive disorders, such as acidosis and bloat, can be higher when feeding barley diets compared with corn-based diets; however, these problems can be effectively managed.

Alfalfa should never be used as the roughage source with a barley-based diet because it greatly increases the likelihood of bloat. The addition of monensin to the diet aids in the prevention of bloat and acidosis and is generally recommended at levels of 320 to 360 mg per animal per day. Many feeders find that the addition of buffers, such as sodium bicarbonate or calcium carbonate, to the supplement aids in reducing the incidence of acidosis. Sodium bicarbonate is recommended at a level of 0.25 to 0.30 lb/animal/day, and calcium carbonate can be included at 0.5 lb/animal/day.

Increasing the frequency of feeding to twice a day can help reduce the incidence of digestive disorders. The single most important feeding management rule to fol-

**Table 5. Example barley-based feedlot diet fed at the Montana State University research feedlots at Bozeman and Havre.**

| Ingredient | As-fed basis | | Dry matter basis | |
|---|---|---|---|---|
| | (lb/day) | (%) | (lb/day) | (%) |
| Dry rolled barley | 19.87 | 83.75 | 18.18 | 83.00 |
| Chopped straw | 1.41 | 5.94 | 1.32 | 6.00 |
| Oil | 0.64 | 2.69 | 0.64 | 2.91 |
| Supplement | | | | |
| Calcium carbonate | 0.49 | 2.07 | 0.49 | 2.33 |
| Ground wheat midds | 0.48 | 2.02 | 0.45 | 2.04 |
| Sodium bicarbonate | 0.29 | 1.20 | 0.29 | 1.20 |
| Urea | 0.18 | 0.74 | 0.18 | 0.80 |
| Potassium chloride | 0.18 | 0.74 | 0.18 | 0.80 |
| Sodium chloride | 0.11 | 0.46 | 0.11 | 0.50 |
| TM premix[a] | 0.055 | 0.23 | 0.055 | 0.25 |
| Oil | 0.02 | 0.08 | 0.02 | 0.09 |
| Vitamin A, D, E premix | 0.011 | 0.05 | 0.011 | 0.05 |
| Rumensin 60 g/lb | 0.005 | 0.02 | 0.005 | 0.02 |
| Tylan 40 g/lb | 0.003 | 0.01 | 0.003 | 0.01 |

[a]Contained 20.0% Mg, 6.0% Zn, 4.0% Mn, 5.0% Fe, 2.7% S, 1.5% Cu, .11% I, .01% Se, and .01% Co.

low when feeding high barley diets is to feed animals within 15 minutes of the same time every day. An example feedlot diet used at the Montana State University research feedlots at Bozeman and Havre is included in Table 5.

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