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Barley Grain and Forage for Beef Cattle

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Barley is an ancient crop dating back to 7000 B.C. and is considered one of the most widely adapted grain crops in the world. Barley is the fourth most important cereal grain in the world, with uses by humans and animals for food, feed and beverages. Grown in temperate regions of the world, barley is more tolerant to drought and saline soils than other cereal grains.

This publication provides information on the nutritional value of barley as feed for livestock when harvested as grain or forage. Guidelines on feeding and processing methods are included, as well as comparative research data on animal performance.

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Energy and Protein Content of Feed Barley

Barley grain is used primarily as an energy and protein source in beef cattle diets. The nutrient content of barley (Table 1) compares favorably with that of corn, oats, wheat, milo and field peas.

The energy content of barley is slightly lower than the energy value of corn and of wheat, partially due to its higher fiber content (neutral detergent fiber, or NDF, and acid detergent fiber, or ADF). The crude protein content of barley is higher than in corn and similar to wheat and oats, but lower than in field peas.

Mineral and Vitamin Content of Feed Barley

All cereal grains are low in calcium and relatively high in phosphorus (Table 2), necessitating the use of supplemental calcium in high-grain diets for beef cattle. The phosphorus content of barley is similar to that of corn and sorghum but lower than in wheat or oats. Barley is higher in potassium than other feed grains. Barley is higher in vitamins A and E than the other major cereal grains as well.

Effect of Barley Varieties on Nutritional Value

Barley varieties generally are classified as two-row or six-row, malting or feed type, covered or hull-less, and floury or waxy starch. Two-row varieties generally produce plumper kernels and higher test weights that are higher in starch than six-row varieties; however, average nutrient composition is generally only slightly different. Two-row barley generally is more adapted to dry growing conditions. Several studies comparing two- and six-row barley varieties have not provided any clear-cut advantage for feeding.

Barley quality parameters for North Dakota production are provided in Table 3. Varieties designated as malting types often are used as feed and discounted in price when the grain lot does not meet the criteria for malting grade (low protein, high test weight, high percent plump, low percent thin kernels and low deoxynivalenol [DON] level). High protein content is desirable in feed varieties. Hull-less barley has lower fiber and higher protein and energy levels than covered barley.

Table 1. Nutrient content of various feed grains.

	Barley*	Corn*	Wheat*	Oats*	Sorghum*	Field Peas**
	Dry-matter basis					
Energy						
TDN, %	88	90	88	77	82	87
NE_m (Mcal/kg)	2.06	2.24	2.18	1.85	2	2.25
NE_g (Mcal/kg)	1.4	1.55	1.5	1.22	1.35	1.48
Protein						
Crude protein (%)	13.2	9.8	14.2	13.6	12.6	25.2
Undegradable protein (% of CP)	27	55	23	17	57	30
Fiber						
Neutral detergent fiber (%)	18.1	10.8	11.8	29.3	16.1	11.4
Acid detergent fiber (%)	5.8	3.3	4.2	14	6.4	6.7

* NRC, 1996
** Lardy et al., 2009
TDN = Total digestible nutrients
NEm = Net energy for maintenance
NEg = Net energy for gain

Growing conditions and cultural practices may have a much larger effect on nutrient content and animal performance than varietal differences. Variation in weather in barley-growing regions, year effect, soil fertility, pest management and harvest proficiency can affect barley grain quality significantly. Bushel weight or other quality characteristics may be more useful in assessing feeding value than relying on variety alone. While opportunities exist for increasing the feeding value of barley through varietal selection, differences in feed value due to agronomic choices and growing conditions also pertain.

Table 2. Mineral and vitamin content of major cereal grains.

	Barley*	Corn*	Wheat*	Oats*	Sorghum*	Peas**
Calcium, %	0.05	0.03	0.05	.0.1	0.04	0.11
Phosphorous,%	0.35	0.32	0.44	0.41	0.34	0.39
Potassium, %	0.57	0.44	0.40	0.51	0.44	1.02
Mangesium,%	0.12	0.12	0.13	0.16	0.17	0.12
Sodium, %	0.01	0.01	0.01	0.02	0.01	0.04
Sulfur, %	0.15	0.11	0.14	0.21	0.14	0.20
Copper, ppm	5.3	2.5	6.5	8.6	4.7	9.0
Iron, ppm	59.5	54.5	45.1	94.1	80.8	65.0
Manganese, ppm	18.3	7.9	36.6	40.3	15.4	23.0
Selenium, ppm	_	0.14	0.05	0.24	0.46	0.38
Zinc, ppm	13.0	24.2	38.1	40.8	1.0	23.0
Cobalt, ppm	0.35	_	_	0.06	_	0.13
Molybdenum, ppm	1.16	0.60	0.12	1.70	_	0.8
Vit A , 1,000 IU/kg	3.8	1.0	_	0.2	0.1	_
Vit E , 1,000 IU/kg	26.2	25.0	14.4	15.0	12.0	_

* NRC, 1996
** Hickling, 2003.

Table 3. Barley quality summary for North Dakota.*

Year	Test Wt lb/bu	Protein %	Moisture %	Thins %	Plump %
2011	45.2	12.90	13.30	4.10	75.00
2010	48.0	12.30	13.70	1.60	88.40
2009	48.5	11.80	13.60	0.90	91.40
2008	47.0	12.70	12.70	2.90	75.50
2007	46.6	12.50	12.30	3.80	74.50
2006	46.7	12.90	12.00	8.10	57.30
2005	45.9	12.80	12.70	3.60	74.70
2004	47.5	12.70	14.00	2.80	79.60
Average	46.9	12.58	13.04	3.48	77.05

*North Dakota Barley Council Crop Quality Summary 2004-11

Impact of Test Weight on Feed Value of Barley

There is no strong consistent relationship between barley test weight and feedlot performance of beef cattle until test weights decrease significantly. There appears to be a threshold of about 44-45 pounds per bushel test weight where gains are similar to heavier barley but efficiency tends to decrease with decreasing test weight. At less than 43 pounds bushel weight, gains and efficiency are severely affected. Light test weight barley may be a mixture of shrunken and normal sized kernels, in some cases screened during seed cleaning or in preparation of malting barley.

Processing Barley Grain for Beef Cattle

Whole Barley

A number of studies have investigated whole barley versus processed barley for beef cattle. In general, animal performance with processed barley was greater than when whole barley was fed. Whole barley fed to beef steers averaged 52.5 percent digestibility, while dry rolled barley was digested at 85.2 percent (Toland, 1976). In this study, 48.2 percent of whole barley kernels were recovered in the feces

Barley has a fibrous hull, necessitating some form of processing for optimum utilization. Whole barley kernels are relatively undamaged during mastication, compared with corn (Beauchemin et al. 1994). This emphasizes the need for mechanical processing if beef cattle are to use barley effectively.

Dry-rolling Barley

Dry-rolling is the most common and least expensive processing method. Barley should be crushed or cracked so each kernel is broken into two or three pieces. A single-stage roller mill with ten to twelve grooves per inch works better than a roller with six to eight grooves (commonly used for processing corn or peas).

Hammer-milling barley is not recommended for feedlot cattle, but if it is the only processing method available, a large screen and slow rotor speed will reduce the amount of fines. The grain should not be finely ground but rolled coarsely, with a particle size not less than about 3,000 microns.

Barley ferments rapidly in the rumen (Figure 1) compared with some other grains and fine grinding accelerates this process. Small particle size increases the surface area exposed and rate of fermentation, increasing the potential for (sub-acute) acidosis, founder and poor feed conversions. Feed additives such as ionophores and some yeast products help maintain a stable rumen environment, but proper grain processing, mixing of the ration, and inclusion of some other fiber in the rations is critical for stable intake and digestion.

Variation in kernel size makes precise processing more difficult. In some cases, light and heavy barley may be blended to make a certain bushel weight grade prior to sale. For instance, barley weighing 50 pounds per bushel (lbs/bu) and 40 lbs/bu may be blended to produce barley weighing 45 lbs/bu. Processing separate lots prior to mixing and feeding will improve the consistency of the feed.

Figure 1. Grain sources categorized by rate of ruminal starch digestion.[1]

FASTER

Dry-rolled Wheat
Steamrolled Barley
Dry-rolled Barley
Temper-rolled Barley
Whole Barley
High-moisture Corn (bunker)
Flaked Wheat
Steam-flaked Corn
Steam-flaked Sorghum
High-moisture Corn (stored whole)
Dry-rolled Corn
Reconstituted Sorghum
Dry Whole Corn
Dry-rolled Sorghum

SLOWER

[1]Adapted from Stock and Britton (1993)

Tempering Barley

Tempering involves adding water to barley and allowing it to soak for 12 to 24 hours to increase the moisture level prior to rolling. The target moisture content is 18 to 20 percent. Higher-moisture barley rolls more easily, resulting in more of a flaked product than dry, hard pieces of barley kernels. The advantages of tempering include fewer fines produced during the rolling process and improved ration acceptability. Rolling tempered barley required 11.3 percent less energy than rolling dry barley (Combs and Hinman (1985). Tempering and rolling barley increased intake and gain vs. dry rolling in some studies and improved efficiency in other trials (Hinman and Combs, 1983, 1989; Wang et al., 2003). Decreasing the flake thickness of tempered rolled barley increased the digestibility of starch (Beauchemin et al., 2001).

Harvesting High-moisture Barley

High-moisture barley grain can be harvested up to 12 days sooner than dry barley with up to 16.7 percent more yield due to reduced field losses (McLelland, 2008). Moisture at harvest should be 25 to 30 percent, with higher moisture levels possible but kernel fill may not be complete. High-moisture grain must be processed immediately and stored as one would silage. Appropriate preparations for high-volume processing and storage are needed to facilitate rolling or grinding and storage of grain being harvested. Bunker or upright silos or large plastic bags are useful for this purpose. Properly processed and stored, high-moisture barley will ensile and become brownish yellow, giving off a distinctive fermented malt-alcohol odor. High-moisture barley feeds as well as dry barley with the advantages of extra yield and the grain is already processed for feeding. (See www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex101)

Pelleting Barley

Barley starch may act as a binder in manufactured pellets but the optimum level of inclusion has not been determined. Pelleting barley in combination with other ingredients may work in modest energy growing diets; however, dry rolled barley supported improved performance over pelleted barley in finishing trials (Williams et al., 2008).

Steam-rolling Barley

No advantages in average daily gain, feed intake and feed efficiency were observed when steam-rolling (or flaking) was compared with dry-rolling or temper-rolling barley in feedlot diets. While marbling scores increased for steers fed steam-rolled barley (Hinman and Combs, 1984), other trials have reported mixed results for carcass quality (Grimson et al., 1987; Zinn, 1993; and Engstrom et al., 1992).

Barley Grain in Growing and Finishing Feedlot Diets

Growing Diets

Barley is an excellent feed grain in forage-based diets. Corn silage-based rations with dry-rolled barley, chopped hay, distillers grains and a commercial supplement have been used frequently for weaned steer calves at the Carrington Research Extension Center. Barley is included in the total mixed ration (TMR) at 6 or more pounds per head daily, depending on the gain goals for the cattle.

Dry-rolled barley added to grass silage-based diets increased weight gains and improved feed efficiencies for growing calves. (Berthiaume et al., 1996; Flipot et al., 1992; Steen, 1993; Viera et al., 1990). Ground barley (processed to a smaller particle size than dry-rolled barley) should be fed in forage-based diets in limited amounts because the smaller particle size can induce digestive problems.

Ground barley fed at 1.1 percent of body weight provided similar energy to corn fed at 1 percent of body weight. Barley provided more rumen-degradable protein, which supports improved forage (NDF) digestion (Brake et al., 1989). Barley fed at less than 4 pounds per head per day in a forage- or silage-based diet for wintering or growing cattle or for beef cows can be processed to a smaller particle size because the increased fermentation rate is offset by the high proportion of forage in the diet.

High-forage diets increase the passage rate in the gastrointestinal tract, allowing less time for digestion of larger particles of grain. In addition, the dusty nature of finely ground barley is mitigated by moist silage, molasses, fat, liquid supplements or other ingredients. Bengochea et al., (2005) conducted three trials evaluating the impact of barley particle size and degree of processing for cattle fed growing diets. Barley processed to a smaller particle size improved starch digestion and feed efficiency in cattle fed medium-concentrate growing diets.

Barley can be added during the ensiling of grass or corn silage to increase energy and protein, but it should be rolled for optimum animal performance (Jacobs et al., 1995). Adding barley to moist forages at ensiling increases dry-matter percent and reduces effluent losses, but less precision results in the ration when feed ingredients are mixed at the silage pile.

Barley in Finishing Diets

Barley can be used as the exclusive grain in finishing rations. Best results are obtained when the TMR includes a modest amount of forage and an ionophore at the recommended rate. Exceptional bunk management is required to keep cattle on feed when forage levels are minimized (below 12 to 15 percent). Forage quality may affect gains and feed efficiency, but alfalfa should not be fed in rations with a high percentage of barley due to the potential for bloat.

Blending Grains

Feeding more than one grain may have some advantages due to the palatability of multiple feed grains in a ration and the complementary rates of ruminal starch digestion. Blending grains can help stabilize rumen function, resulting in more consistent intake. Corn and barley fed at reciprocal inclusion levels of 0, 33, 67 and 100 percent grain in finishing diets supported equal gains and feed efficiency when distillers grains were included in all the rations at 23 percent of the diet (Anderson and Ilse, unpublished data). Barley and corn combinations performed similarly in other trials (Duncan et al., 1995). Field peas (grown in the same eco-regions as barley) make an excellent complementary protein source in barley-based rations (Anderson and Iles, 2008).

Barley and Distillers Grains

Distillers grain is especially important in barley-based diets because bypass protein from the ethanol coproduct balances the highly rumen-degradable protein of barley. In addition, distillers grain provides energy from fat (corn oil) and additional fiber from corn bran that may mediate the fermentation rate of barley starch. Any level of distillers grain (12, 24 or 36 percent of dry matter) added to barley-based growing diets improved feed intake and gain. In a companion finishing study with the same levels of distillers grain tested, 24 percent distillers grain supported the fastest gains, and all carcass traits except rib-eye area improved linearly with increasing distillers grain levels (Anderson et al., 2011).

Feed Additives

Cattle fed barley will benefit from including an ionophore in the ration to stabilize rumen function and maximize feed efficiency and gain. Ionophores improve gains in high-forage diets without affecting intake, while in finishing rations, gain is not affected but feed intake generally is reduced, resulting in greater feed efficiency.

Some commercial products such as yeasts and enzymes may be effective in barley-based diets. Consider unbiased research when selecting feed additives.

Barley is higher in fiber than other cereal grains (NRC, 1996) and the fibrous hull is relatively low in digestibility. Rolled barley treated with an enzyme mixture of cellulase and xylanase enzymes increased ADF digestion by 28 percent (Krause et al., 1998). Fibrolytic enzymes (xylanase) used in barley rations resulted in improved feed efficiency with no differences in average daily gain or feed intake (Beauchemin et al., 1997). More research in this area is warranted as new products are developed.

Barley Grain for Grazing Yearling Cattle

Increasing the level of supplemental barley grain (10, 30 or 50 percent of the diet dry matter) for grazing cattle consuming brome grass resulted in increased average daily gains and improved feed efficiencies (Leventini, 1990); however, digestion of NDF decreased as barley supplementation increased.

Soybean meal (1.06 lbs./head/day), beet pulp (2.93 lbs./head/day), barley (2.83 lbs/head/day), and corn (2.84 lbs/head/day) were compared as supplements for brome grass (9.9 percent CP) diets for beef steers (Carey 1993). Forage intake decreased with each of the supplements compared to non-supplemented cattle, but total intake did not differ between treatments. Barley supplementation resulted in lower NDF digestibility compared with other treatments. Forage intake decreased when barley was fed at 5.9 lbs/head/day to beef steers consuming grass hay (Westvig, 1992). Forage intake was reduced when 4 or 6 pounds of barley was fed but was not affected when 2 pounds of barley was used as a supplement. Digestible OM intake was higher in diets which contained supplemental barley, however. (Lardy et al., 2004).

Barley Grain in Beef Cow Diets

Barley is a very useful supplement for gestating beef cows fed low-quality forage. The level of barley fed will affect forage digestion (Caton et al., 1998), with a maximum of 4 or 5 pounds per head per day recommended. Barley provides energy from starch and rumen-degradable protein (nitrogen) necessary for healthy populations of forage-digesting bacteria in the rumen. Too much barley (starch) will affect the population of fiber-digesting microbes negatively and reduce forage digestibility. If higher levels of supplemental energy are required, feeds with more digestible fiber (such as barley malt sprouts, wheat midds, soy hulls, corn gluten feed, beet pulp, oilseed meals and distillers grains) may be more useful. The negative effect of excessive starch in a high-forage diet is not considered in ration-balancing software.

Momont et al. (1994) compared barley fed at 4.5 lbs/head/day with beet pulp fed at 5.7 lbs/head/day in ammoniated straw-based diets for cull cows. Both were equally effective as supplemental feeds. Cows fed the barley supplement consumed more ammoniated straw than cows fed the beet pulp supplement, and no adverse effects of barley on forage digestibility were noted.

Dry, gestating beef cows were fed a barley-based protein supplement (2 lbs/head/day; 70 percent barley, 30 percent cottonseed meal) while grazing native range in southeastern Montana. Cows fed a barley-cottonseed meal cake gained 31 pounds during the trial. Cows fed 2.75 pounds of alfalfa cubes per cow per day had similar performance (Cochran et al., 1986). Unsupplemented cows lost 24 pounds during the study.

Vomitoxin in Barley

Vomitoxin, also known as deoxynivalenol (DON), is a trichothecene mycotoxin produced by Fusarium fungi in scab-infected grain. DON-infected barley is rejected for malting at relatively low levels (0.5 up to 4 parts per million, or ppm). While DON can cause problems for swine (reduced feed intake, vomiting) no evidence exists that beef cattle are affected adversely based on multiple research trials with cows and feedlot cattle.

First-calf heifers were fed dry-rolled barley with 36.8 ppm DON at 8 lbs/head/day during gestation and 12 lbs/head/day during lactation (Anderson et al., 1995) with no negative effects observed. Finishing cattle were fed DON-infected barley with up to 12.6 ppm of DON in the entire ration without affecting feedlot performance or carcass characteristics (Boland et al., 1994). Barley infected with DON up to 21 ppm was fed to growing and finishing cattle without adversely affecting feedlot performance or carcass characteristics (DiConstanzo et al., 1995; Windels et al., 1995).

However, grains contaminated with DON often are contaminated with other mycotoxins encompassing a wide range of compounds. Some research has suggested effects of mycotoxins on milk composition, weight gain, immune function and reproductive performance in ruminants (Martin, 2009). Current FDA guidance states that grain with 10 ppm DON should not be fed at more than 50 percent of the diet (www.ngfa.org/files/misc/Guidance_for_Toxins.pdf).

Barley as Forage

Barley is a cool-season crop that can be planted early into cool soils. Barley is a very competitive plant that matures quickly and can be harvested for forage in approximately 58 to 65 days. Given the short growing season, barley could be planted in some environments for double cropping. The seed cost for barley is low, and seed can be saved from most varieties for reseeding. Some specific barley varieties have been developed for annual forage, and seed is often commercially available.

Barley varieties developed for forage are generally awnless and can be harvested at a later stage of maturity (milk-soft dough stage) compared with grain varieties. Forage barley varieties can be two-row or six-row types.

Awned varieties developed for grain production can be used for forage although they need to be harvested shortly after heading to avoid mature awns, which can be irritating to the mouth of cattle.

Barley can be grown as a monoculture or planted with peas to produce forage with increased protein and greater yield. Trials at various university and seed company plot sites around the region provide localized forage yields and quality information.

Forage barley or barley-pea mixtures can be harvested and stored as haylage if the crop is wilted to 40 to 60 percent moisture. See NDSU Extension publication AS-1252, "Haylage and Other Fermented Forages," at www.ag.ndsu.edu/pubs/ansci/dairy/as1252.pdf for more information on haylage harvest and storage guidelines.

Forage or grain varieties of barley may be harvested as whole-crop silage or as "head chop," in which the top of the plant or head is cut and allowed to cure to proper moisture, then chopped and stored as silage. Forage barley or mixed barley-pea stands can be harvested as dry hay as well.

The stage of maturity at harvest will make a significant difference on the quality of the forage. Harvesting at heading to milk stage is recommended for optimum quality, although the soft dough stage may yield slightly more forage and still provide reasonably good quality. The addition of peas allows the forage mix to be harvested at a later stage to increase yield while still maintaining high-quality forage.

Barley or barley pea mixtures harvested as hay or silage can be used as forage in feedlot rations as well as in beef cow diets. Barley straw may be used as forage when properly supplemented, but awns are a concern.

Conclusions

Barley grain is a useful feedstuff for several different classes of beef cattle. When properly processed, mixed and fed, barley is an excellent feed grain. It can be used in growing and finishing diets for feedlot cattle, as supplement in forage rations for replacement heifers, and as an energy and protein source for gestating and lactating beef cows. Beef cattle seem to be less affected by DON than monogastric animals.

Barley processing requires careful attention to maximize digestion efficiency and maintain stable rumen function. Thorough mixing of rations and good bunk management are essential with barley rations, as with other grains.

For more information on this and other topics, see www.ag.ndsu.edu

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