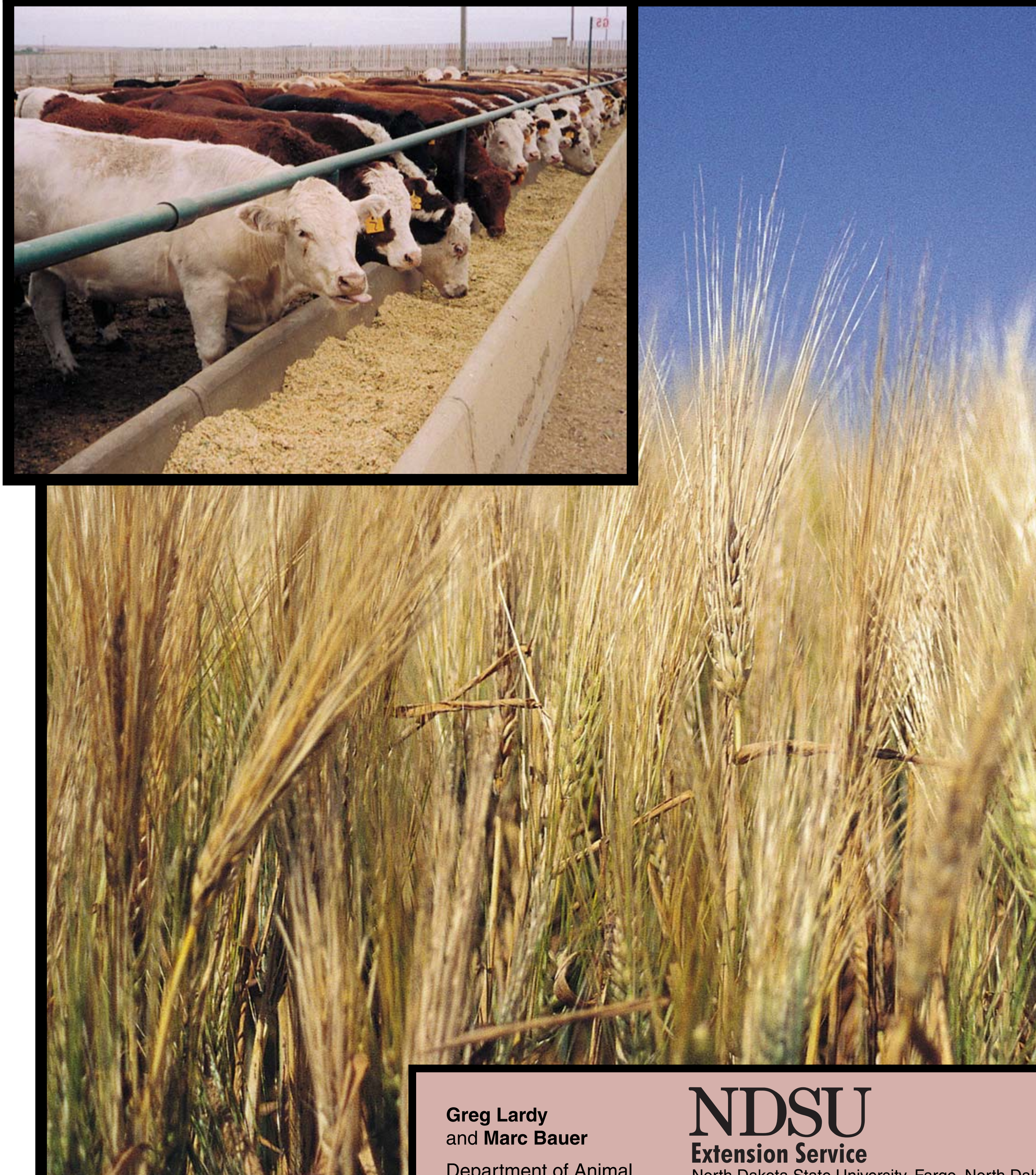
EB-70

Feeding Barley to Beef Cattle



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Introduction

Barley is an important feed grain in many areas of the world not typically suited for corn production, especially in northern climates. Barley is the principal feed grain in Canada, Europe, and in the northern United States.

The purpose of this review is to compare the nutritive and feeding values of barley to other common feed grains, review data from feeding trials involving barley, and offer barley feeding recommendations.

Energy and Protein Content

Barley 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, and milo as reported by the National Research Council (NRC, 1996).

The crude protein content of barley is higher than corn and similar to other major feed grains. The energy content (TDN, NE_m, NE_g) of barley is slightly lower than the energy value of corn and may be partially attributed to its higher fiber content (NDF, ADF).

Table 2 lists the energy and protein content of barley and corn as reported by the National Research Council (NRC, 1996). Their findings have recently been challenged (Owens et al., 1997; Table 2). There appears to be some discrepancy between the energy values reported by the NRC (1996) and the values reported by Owens et al. (1997). The reasons for this discrepancy are not readily apparent; however, Owens et al. (1997) cited more extensive barley processing in observations included in their data set as one possible explanation. Barley variety may also affect the observed variation. The effects of barley varieties are discussed later in this report. Data reported by the NRC (1996) also indicate that barley is more variable than other grains, which also may explain a portion of the discrepancy noted between the two references.

Table 1. **Nutrient content of various feed grains** (NRC, 1996).

	Barley	Corn	Wheat	Oats	Sorghum
TDN (%)	88	90	88	77	82
NE_m (Mcal/kg)	2.06	2.24	2.18	1.85	2.00
NE_g (Mcal/kg)	1.40	1.55	1.50	1.22	1.35
CP (%)	13.2	9.8	14.2	13.6	12.6
UIP (% of CP)	27	55	23	17	57
NDF (%)	18.1	10.8	11.8	29.3	16.1
ADF (%)	5.8	3.3	4.2	14.0	6.4

Table 2. **Energy and protein content of barley and corn as reported by the National Research Council** (1996) **and Owens et al.** (1997).

	Crude Protein (%)	ME (Mcal/kg)
Barley, NRC	13.2 ± 1.50	3.03
Barley, Owens et al., 1997	—	3.55
Corn, NRC	9.8 ± 1.06	3.25
Corn, Owens et al., 1997	—	3.40

Mineral and Vitamin Content of Feed Barley

Table 3 lists the mineral and vitamin content of feed barley (NRC, 1996). All cereal grains are low in calcium and relatively high in phosphorus, necessitating the use of supplemental calcium in high grain diets for beef cattle. The phosphorus content of barley is similar to corn and sorghum but lower than wheat or oats. Barley is higher in potassium than other feed grains. Barley is higher in vitamin A and Vitamin E than the other major cereal grains.

Table 3. Mineral and vitamin content of major cereal grains (NRC, 1996)**.**

	Barley	Corn	Wheat	Oats	Sorghum
Calcium (%)	0.05	0.03	0.05	0.01	0.04
Phosphorus (%)	0.35	0.32	0.44	0.41	0.34
Potassium (%)	0.57	0.44	0.40	0.51	0.44
Magnesium (%)	0.12	0.12	0.13	0.16	0.17
Sodium (%)	0.01	0.01	0.01	0.02	0.01
Sulfur (%)	0.15	0.11	0.14	0.21	0.14
Copper (ppm)	5.3	2.51	6.48	8.6	4.7
Iron (ppm)	59.5	54.5	45.1	94.1	80.8
Manganese (ppm)	18.3	7.89	36.6	40.3	15.4
Selenium (ppm)	–	0.14	0.05	0.24	0.46
Zinc (ppm)	13.0	24.2	38.1	40.8	0.99
Cobalt (ppm)	0.35	–	–	0.06	–
Molybdenum (ppm)	1.16	0.60	0.12	1.70	–
Vitamin A (1,000 IU/kg)	3.8	1.0	0.0	0.2	0.05
Vitamin E (1,000 IU/kg)	26.2	25.0	14.4	15.0	12.0

Effect of Barley Varieties on Nutritional Value for Beef Cattle

Barley variety (two-row versus six-row, malting versus feed type, covered versus hull-less, floury versus waxy starch, etc.) can impact animal performance independent of growing conditions or cultural practices. However, growing conditions and cultural practices may have a much larger effect on nutrient content and animal performance and may mask any varietal differences. Most of the barley produced in North Dakota is six-row barley used for malting and feeding. In 1996 and 1997, over 90% of the barley acreage in North Dakota was six-row malting varieties. Although varieties have been designated malting or feed types, in practice “feed barley” is barley which has not made malting grade. In the Upper Great Plains, two-row varieties generally produce plumper kernels (and higher test weights) which are higher in starch than six-row varieties; however, average nutrient composition is generally only slightly different (Table 4).

Bradshaw et al. (1996) fed Steptoe (six-row feed variety) and Klages (two-row malting variety) to steers in both growing (31% barley) and finishing (87% barley) diets (both dry-rolled and tempered-rolled). Both varieties had equal bushel weight (52 lbs/bu). No differences in steer performance between the varieties were detected. In six trials over five years, Kercher et

Table 4. Average bushel weight and nutrient composition (DM basis) of North Dakota six- and two-rowed barley varieties.[a]

Nutrient	Six-row	Two-row
Test Weight, lb/bu	46.2	48.4
DM, %	90.6	90.8
NDF, %	21.4	20.0
ADF, %	6.6	6.2
CP, %	12.4	12.9
P, %	.37	.36
Ca, %	.05	.05
Mg, %	.14	.14
K, %	.54	.54

[a] From 1991 through 1997 Regional Barley Crop Quality Report

al. (1986) fed Klages and Steptoe along with other varieties. Feeding Klages increased weight gain once, resulted in no difference three times, and decreased gain twice when compared with Steptoe. Feed efficiency did not differ between varieties.

Ovenell-Roy et al. (1998a and 1998b) fed six different varieties (Andre, Camelot, Clark, Cougbar, Harrington, and Steptoe in Trial 1 and Boyer, Camelot, Clark, Harrington, Hesk, and Steptoe in Trial 2) to steers in a finishing diet (83% barley; steam-rolled) and noted differences between varieties. Cougbar had lower NDF digestibility than Clark and tended to have lower digestibility of other nutrients; as a result, digestible energy was lower for Cougbar than for Clark or Camelot. Steers fed Hesk had poorer feed to gain ratios than steers fed Camelot or Harrington. Hesk also had lower digestibility than Steptoe. The authors concluded that Cougbar and Steptoe had lower nutritional value than other varieties investigated in these studies. In addition, they noted that two-row barleys they evaluated had higher feeding values, in general, than six-row varieties evaluated in these studies. Diet digestibility was closely associated with NDF digestibility in the barley varieties studied.

Boss and Bowman (1996a) fed three varieties [Gunhilde (two-row feed; 50 lbs/bu), Harrington (two-row malting; 49 lbs/bu), and Medallion (six-row feed; 48 lbs/bu)] to steers in a finishing diet (80% barley, dry-rolled). Feeding Medallion resulted in better feed conversions than feeding Gunhilde, with Harrington intermediate. However, intake and gain was reduced when Medallion was fed compared with Harrington and no differences were detected in feed cost per unit of gain for the three varieties. Boss and Bowman (1996b) found no differences in ruminal starch digestion among three different barley varieties (Gunhilde, Harrington, and Medallion).

The majority of the research indicates that year-to-year variation alters the performance of cattle fed different barley varieties. Feeders should use bushel weight or other quality characteristics to assess feeding value, rather than relying on variety alone.

Zinn et al. (1996) fed covered (Leduc; 48 lbs/bu) and hull-less (Condor; 59 lbs/bu) barley to steers in finishing diets (77% barley; both steam-flaked and dry-rolled). Weight gains were similar between covered and hull-less varieties. However, intake was higher for the covered variety, resulting in reduced feed efficiency and dietary energy density. Barley hulls are much less digestible than the endosperm, and removing the hull enhanced feeding value.

Varietal differences will be most noticeable in high-barley finishing diets as opposed to barley fed in growing diets or used as a supplement for cows. Feng et al. (1995) fed Steptoe (feed) and Russell (malting) varieties in grass hay-based diets. No differences due to barley variety were detected in ruminal fermentation characteristics.

Opportunities exist for increasing the feeding value of barley through varietal selection. However, differences in feeding value due to agronomic and growing conditions also exist.

Barley Processing for Beef Cattle

Impact of Test Weight on Feeding Value of Barley

The variety of barley selected by the grower and the growing conditions that the barley is subjected to during the growing season affect barley test weight (bushel weight). However, there does not appear to be a consistent relationship between barley test weight and feedlot performance of beef cattle. Some research reports indicate that animal performance is lower when lighter test weight barley is fed (Hinman, 1978). Hinman (1978) evaluated barleys weighing 42.0, 44.9, 48.9, and 50.9 lbs/bu and reported that animal performance increased as bushel weight increased.

Grimson et al. (1987) compared three different test weights (37, 43, and 52 lbs/bu) and two different processing methods (dry rolling or steam flaking) in high concentrate diets (85% barley) for yearling steers. Bushel weight had no significant effect on average daily gain or feed intake. No significant interactions between processing method and test weight were detected. Feed efficiency for the light test weight (37 lbs/bu) was significantly poorer than the medium (43 lbs/bu) and heavy test weight (51.5 lbs/bu) barleys (5.80, 5.32, and 5.26 for light, medium, and heavy test weights, respectively).

Other research indicates a plateau effect once test weight is greater than 45.7 lbs/bu (Mathison et al., 1991b). Grimson et al. (1987) suggested that feeding value was reduced 0.93 percentage units below 43.4 lbs/bu.

Since light test weight barley is generally a mixture of shrunken and normal sized kernels, it is often more difficult to process than normal or high test weight grain. The variation in kernel size makes setting the processing equipment more difficult. Extra care and attention is necessary to effectively process light test weight barley. In some cases light and heavy barley may be blended to make a certain bushel weight grade. For instance, barley weighing 53 lbs/bu and 43 lbs/bu may be blended to produce barley weighing 48 lbs/bu. This can make uniform processing very difficult.

Whole, Dry- Rolled or Temper-Rolled Barley

A number of studies have investigated whole versus processed barley for beef cattle. In general, animal performance with processed barley was greater than when whole barley was fed. Barley has a fibrous hull, necessitating some form of processing for better utilization. Beauchemin et al. (1994) found that whole barley kernels are relatively undamaged during mastication as compared to corn. This emphasizes the need for mechanical processing if barley is to be effectively utilized by beef cattle.

Dry rolling generally results in marked increases in digestibility of barley. Toland (1976) compared whole and dry rolled barley for beef steers. Digestibility of whole barley averaged 52.5%, while dry rolled barley averaged 85.2%. In this work, 48.2% of all whole kernels fed to beef steers were recovered in the feces. Mathison et al. (1991a), in another comparison involving whole versus dry rolled barley for beef steers, noted that average daily gain was numerically improved when barley was dry rolled (3.03 vs 2.86 lbs/day for dry rolled and whole barley, respectively). However, significant improvements in feed efficiency for cattle fed dry rolled barley were noted (6.28 vs 7.25 lbs of feed per pound of gain for dry rolled and whole barley, respectively). Feed conversion rate and feed costs are the most important factors in determining profitability in the feedlot.

Temper-rolling involves allowing grain to soak for 12 to 24 hours to bring it up to a moisture level of 18 to 20% prior to rolling. Advantages of tempering include fewer fines produced during the rolling process and improved ration acceptability. In addition, Combs and Hinman (1985) noted an energy savings during grain processing of 11.3% for temper-rolling over dry-rolling.

Improvements in average daily gain and dry matter intake with no differences in feed efficiency were noted when dry-rolling was compared with temper-rolling (Hinman and Combs, 1983). Improvements in average daily gain and feed efficiency were noted with no differences in dry matter intake when comparing dry-rolling to temper-rolling (Combs and Hinman, 1989).

Bradshaw et al. (1992) investigated the effects of processing method for barley in growing and finishing diets for beef steers. Treatments included dry rolled barley (DR), tempered/rolled barley (TR; 20% added moisture, 21-23 hour tempering time prior to rolling), tempered/ammoniated/rolled (AR; 3% anhydrous ammonia added) or tempered/ammoniated/whole (AW). In the growing phase, cattle fed AW gained less and had poorer feed conversions compared to AR. No differences in average daily gain or feed efficiency were detected for the DR, TR, and AR treatments in the growing or finishing phases. They concluded that tempering had no effect on average daily gain, but efficiency was improved by 6.8% compared to dry rolled barley.

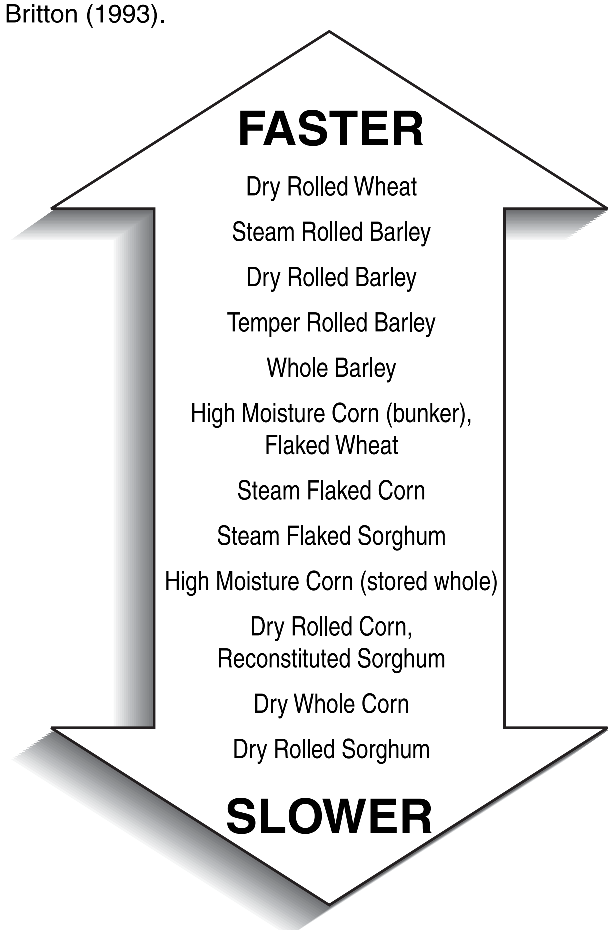
Hinman and Sorenson (1994) investigated the effect of tempering time. Barley was cold tempered to 16% moisture and processed immediately following tempering, rolling 6 hours following tempering, rolling 12 hours following tempering, or rolling 24 hours following tempering. They noted improved steer average daily gain with no differences in feed efficiency when barley was allowed to temper for 12 hours prior to processing.

Additional research investigating the response to tempering and degree of processing concluded that there was no advantage to tempering barley which initially contained 13% moisture (Mathison et al., 1997).

The effects of degree of processing (slight, medium, and crushed) in dry-rolled and temper-rolled barley diets was recently investigated by Mathison et al. (1997). Results indicated that increased degree of processing resulted in better feed conversions. It should be noted that in this study, the percentage of whole kernels by weight in the dry-rolled treatment was 71.6, 42.0, and 12.7% for the slight, medium, and crushed processing methods, respectively. For the temper-rolled treatment the percentage of whole kernels by weight was 83.7, 58.2, and 41.1% for the slight, medium, and crushed processing methods, respectively.

Because of the rapidly fermentable nature of barley (Figure 1), the grain should only be coarsely cracked, not finely ground. Fine grinding barley will result in problems with acidosis, founder, and poor feed conversions. In addition, the dusty nature of finely ground barley rations may cause problems with feed intake unless molasses, fat, liquid supplements, or other ingredients are added to the diet to improve acceptance. The goal of a dry processing system for barley should be to break the kernel in two pieces and to minimize the fines.

Figure 1. Grain sources categorized by rate of ruminal starch digestion. Adapted from Stock and Britton (1993).



Whole barley is not well utilized in diets containing either low or high proportions of grain, according to research conducted in Alberta (Mathison et al., 1991a). These researchers fed diets containing either 33 or 67% barley grain (fed either whole or rolled) and found no significant interactions with barley processing method. Steers fed whole barley had reduced feed conversions regardless of level of barley feeding. They also noted a higher proportion of cattle bloating when fed diets containing whole barley versus rolled barley (of the 62 steers per treatment, 36 steers bloated in the whole barley treatment versus nine for the rolled barley treatment).

Jacobs et al. (1995) compared steer performance when offered diets containing whole barley ensiled with grass silage or rolled barley fed with grass silage. Additions of either whole or rolled barley increased weight gains in steers. Steers offered silage diets mixed with rolled barley had higher weight gains and better feed conversions than steers fed whole barley ensiled with grass silage, indicating that processing barley is necessary for optimal utilization in forage based diets as well. Adding whole barley to grass silage stacks did, however, reduce effluent losses and increase dry matter content of the silage. Jones et al. (1990) added rolled barley to ryegrass silage and noted reduced effluent losses and increased dry matter content of the silage. They noted improved weight gains but similar feed efficiencies when these silages were fed to beef cattle.

Staigmiller and Adams (1989) compared whole barley, rolled barley, or rolled oats for young, early-weaned beef calves. They noted that calves fed whole or rolled barley had similar average daily gains, but feed efficiency was improved by rolling. Economides et al. (1990) found similar results in young calves fed high grain rations. Calves fed pelleted barley diets had growth rates similar to calves fed whole barley diets. However, feed efficiency was better for the pelleted diet compared to the whole barley diet.

Dry-Rolling versus Steam Flaking

Hinman and Combs (1984) noted no advantages in average daily gain, feed intake, and feed efficiency for steam-rolling over dry-rolling or temper-rolling. Marbling score was increased for steers fed steam-rolled barley, however.

Grimson et al. (1987) found no differences in average daily gain or feed efficiency when comparing dry rolling to steam flaking in barley based finishing diets. Cattle fed steam flaked barley tended (P = .10) to have higher dry matter intakes (20.4 versus 19.7 lbs/head/day). In addition, cattle fed steam flaked diets had lower incidence of liver abscesses compared to cattle fed dry rolled barley.

Zinn (1993) compared dry rolled barley (30.2 lbs/bu), coarse steam flaked barley (30.2 lbs/bu), thin steam flaked barley (14.7 lbs/bu), and steam flaked corn (24 lbs/bu) in 90% concentrate diets for finishing steers. The feeding value of dry rolled barley, coarse steam flaked barley, and thin steam flaked barley was estimated to be 90, 92, and 96% the energy value of steam flaked corn, respectively.

Engstrom et al. (1992) found no advantage for steam flaking over dry rolling in a trial conducted with 750 pound beef steers. Average daily gain, feed efficiency, and dry matter intake were not significantly different for dry rolled versus steam flaked barley.

Malcom and Kiesling (1993) evaluated in situ degradation in a 4 x 2 x 2 factorial design that evaluated grain type (barley, corn, wheat, and sorghum), processing (grinding versus flaking), and conditioning (no conditioner versus conditioner; E-Z Flake, Loveland, CO). Barley was flaked to a weight of 19 lbs/bu in the steam flaking treatment. Grains were ground to pass through a 3.2-mm screen in a hammer mill. Only small differences in degradability were detected. Conditioning did not consistently alter digestibility of any of the grains. They concluded that grinding and steam flaking were equally effective at increasing digestibility and susceptibility of the grain to microbial attack.

Using Barley in Diets for Backgrounding and Stocker Cattle

Fredrickson et al. (1993) evaluated the effect of different grain sources (barley, corn, wheat, sorghum) on ad libitum forage intake and digestion in beef steers fed grass hay. Grains were made isonitrogenous with the addition of urea and were fed to provide 0.25% of body weight as starch (approximately 3.75 pounds of organic matter per head per day). No differences in hay intake or digestibility were noted among the various grain supplements.

Using Barley in Diets for Growing Cattle

Numerous studies have evaluated barley as a supplement for various grass silages (Berthiaume et al., 1996; Flipot et al., 1992; Steen, 1993; Viera et al., 1990). Similar results were found in each of these studies. Adding rolled barley to grass silage based diets increased weight gains and improved feed efficiencies.

Brake et al. (1989) fed ground corn or ground barley supplements to steers consuming orchardgrass or bermudagrass hay diets. Barley was fed at 1.1% of body weight and corn was fed at 1.0% of body weight. Grains were fed to provide similar levels of supplemental digestible energy. Total intake was greater for cattle supplemented with barley than corn with either forage. Digestion of NDF was greater in steers fed no supplement compared with either grain supplement. In addition, digestion of NDF was greater for barley-supplemented cattle compared to corn-supplemented cattle, suggesting fewer negative associative effects.

Galloway et al. (1993) supplemented cattle grazing bermudagrass pastures with whole corn (1.0% body weight), ground corn (1.0% body weight), ground sorghum (1.08% body weight), ground wheat (1.02% body weight), or ground barley (1.07% body weight). Grains were fed to provide similar levels of supplemental digestible energy. Steers receiving barley gained faster than non-supplemented control cattle and cattle receiving wheat, but gained slower than cattle receiving ground corn, whole corn, or ground sorghum.

Corn versus Barley Comparisons in Feedlot Cattle

Duncan et al. (1991) replaced high moisture corn with steam rolled barley in diets containing 65% grain, 8% corn silage, 8% alfalfa hay, 5% supplement, and 14% potato process residue fed to yearling steers. No differences were observed in average daily gain. However, dry matter intake declined cubically as level of barley increased. Feed efficiency changed quadratically as the level of barley increased (Table 5).

Gray and Stallknecht (1988) compared whole corn to dry rolled barley in finishing diets for beef calves. Cattle were fed diets which consisted of 84% grain, 12% alfalfa haylage, and 4% supplement. They found no differences in average daily gains (avg. = 3.0 lbs/day) or feed efficiencies (avg. = 5.9 lbs of feed per lb gain). The incidence of digestive disorders was not influenced by dietary treatment. Carcass characteristics were similar for barley and corn fed cattle.

Table 5. Effect of grain source and processing method on performance of yearling steers (Duncan et al., 1991).

	100% HMC	67% HMC: 33% Barley	33% HMC: 67% Barley	100% Barley	50% Barley: 50% DRC	100% DRC	100% SRC
ADG (lbs/day)	3.7	3.7	3.5	3.8	3.9	3.8	3.7
DMI[a] (lbs/day)	26.6	27.6	26.1	25.9	26.5	27.2	26.2
F:G[b]	7.2	7.4	7.4	6.8	6.8	7.2	7.0

HMC = High Moisture Corn, DRC = Dry Rolled Corn, SRC = Steam Rolled Corn.
ADG = Average Daily Gain, lb/day; DMI = Dry Matter Intake, lb/day; F:G = Feed:Gain, lb of feed per lb of gain.
[a]Cubic effect of barley level with HMC ($P < .05$).
[b]Quadratic effect of barley level with HMC ($P < .05$).

Combs and Hinman (1988) replaced dry-rolled corn with tempered barley in high grain (6% roughage) finishing diets for steers. All diets contained 85% grain. Grain proportions were 100% dry rolled corn; 67% dry rolled corn:33% tempered barley; 33% dry rolled corn:67% tempered barley; and 100% tempered barley. No significant differences were noted in average daily gain, feed intake, or feed efficiency as tempered barley replaced dry rolled corn. Carcass weight responded quadratically to treatment (grain combinations had greater carcass weights than did single grains). Yield grade and 12^{th} rib fat also responded quadratically to increasing level of barley in the diet (grain combinations had higher yield grades and more 12^{th} rib fat than did single grains).

Blending Barley With Other Grains

Mixtures of grain sources have some advantages in some beef cattle feeding programs due to synergistic effects of blending grain sources with different rates of ruminal starch digestion (Bock et al., 1991; Kreikemeier et al., 1987; Stock et al., 1987). Blending grains may help alleviate subacute acidosis problems which may be encountered when feeding grains which ferment rapidly in the rumen (Figure 1). Zinn and Barajas (1997) evaluated various flake thicknesses of blends of steam flaked corn and barley for finishing beef steers. Four treatments were used: 1) steam flaked barley (flake density = 20.2 lbs/bu); 2) blend of two-thirds barley and one-third corn with a flake density of 27.9 lbs/bu; 3) blend of two-thirds barley and one-third corn with a flake density of 24.0 lbs/bu; and 4) blend of two-thirds barley and one-third corn with a flake density of 20.2 lbs/bu, as the grain portions of the diet. Grain blends were mixed before flaking. No treatment effects on average daily gain, feed efficiency, or feed intake were observed. The authors concluded that barley could be blended with corn prior to flaking with no adverse effects on cattle performance or flaking properties of the grains.

Responses to Fat Supplementation in Finishing Diets

Research conducted in California has noted positive growth responses to fat supplementation in barley-based finishing diets (Zinn, 1988; Zinn, 1989). Steers fed 4 and 8% fat (yellow grease or blended animal and vegetable fat) had increased weight gains and improved feed efficiencies compared to steers fed barley based finishing diets with no supplemental fat added.

Research conducted at Washington State University evaluated the effect of adding graded levels of beef tallow to barley- based lamb finishing diets (Nelson et al., 1998). Addition of tallow resulted in a linear increase in diet metabolizable energy. Previous research at the same location, noted decreases in methane production when tallow was included in barley-based finishing diets (Criswell et al., 1996).

Responses to Enzyme Treatment of Barley in High Grain Diets

Barley is higher in fiber than other cereal grains (NRC, 1996). In addition, the fiber in barley is relatively low in digestibility (Hepton et al., 1995). Krause et al. (1998) treated rolled barley with Pro-Mote® (Biovance Technologies, Inc., Omaha, NE), which contained a mixture of cellulase and xylanase. Total tract ADF digestion was increased 28% by the addition of this enzyme mixture. More work in this area may be warranted to improve the feeding value of barley.

Adding fibrolytic enzymes to high concentrate (95% barley) diets resulted in a significant improvement in feed efficiency with no differences in average daily gain or feed intake (Beauchemin et al., 1997). An enzyme mixture containing high xylanase activities was used in this study.

Barley as a Supplement in Forage Based Diets

Using Barley in Diets For Beef Cows

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

Ward et al. (1990a) evaluated the effect of rolled barley (3.0 lbs/hd/day) or monensin supplements alone or in combination on forage intake and digestibility with beef steers grazing native range in southeast Montana during June, July, and August. Rolled barley decreased forage intake but had no impact on forage digestibility. Total intake (forage + supplement) was not impacted by treatment.

Ward et al. (1990b) evaluated the effect of a barley based protein supplement (1.76 lbs/head/day; 26% CP; 55% barley, 40% soybean meal, 5% molasses) or monensin (Rumensin®) for steers grazing native range in November and January. Forage intake was not influenced by supplementation. However, forage digestibility was increased by the barley-based protein supplementation.

Cochran et al. (1986) used a barley-based protein supplement (2 lbs/head/day; 70% barley, 30% cottonseed meal) for dry, gestating cows grazing native range in southeastern Montana. Cows fed the 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. Unsupplement-ed cows lost 24 pounds during the study.

Leventini (1990) investigated the effects of increasing levels of supplemental barley (10, 30 or 50% of the diet dry matter) and the addition of a ruminal buffer for steers fed brome hay diets in a 3 x 2 factorial design. Increasing the level of barley resulted in increased average daily gains and improved feed efficiencies. Ruminal buffer (sodium sesquicarbonate) had no effect on performance. Digestion of NDF decreased as barley supplementation increased.

Carey (1993) compared 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) as supplements for brome hay (9.9% CP) diets fed to beef steers. Supplemental CP intake was equalized using soybean meal. Forage intake (percent of body weight) was decreased for all supplements compared to non-supplemented cattle. Total intake did not differ among treatments. Barley supplementation resulted in lower NDF digestibility compared with other treatments.

Westvig (1992) also noted reduced forage intake when feeding barley (5.9 lbs/head/day) to beef steers consuming grass hay. Ulmer et al. (1990) supplemented grass hay diets with increasing levels of barley (2, 4, and 6 lbs/head/day). Forage intake was reduced when 4 and 6 pounds of barley were 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.

Feeding Vomitoxin Infested Barley to Beef Cattle

Vomitoxin (DON, deoxynivalenol) is a trichothecene mycotoxin produced by Fusarium fungi in scab infected grain. While vomitoxin can cause problems in performance when feeding swine, no evidence exists that beef cattle are adversely affected. Research conducted at the NDSU Research Center in Carring-ton suggests that growing and finishing cattle can be fed vomitoxin levels up to 12.6 ppm in the ration without adversely affecting feedlot performance or carcass characteristics (Boland et al., 1994). No adverse effects were detected when vomitoxin-infested barley (36.8 ppm DON; fed at 8 lbs/head/day during gestation and 12 lbs/head/day during lactation) was fed to gestating and lactating heifers (Anderson et al., 1995). Two research trials conducted at the University of Minnesota indicate that up to 21 ppm DON in the diet can be fed to growing and finishing cattle without adversely affecting feedlot performance or carcass characteristics (DiConstanzo et al., 1995; Windels et al., 1995).

Research conducted at North Dakota State University with gestating and lactating ewes suggested that diets containing up to 25 ppm vomitoxin (DON) throughout pregnancy have no effect on weight gain in pregnant ewe lambs, reproductive performance of the ewe lambs, or survivability of the lamb crop (Haugen et al., 1996).

Conclusions

Barley is a useful feedstuff for beef cattle. It contains higher crude protein levels than corn. Consequently, when used as a supplement, lower levels of supplemental protein are required. This should be taken into account when pricing barley.

When properly managed, barley has an energy value similar to corn in high-grain finishing rations. In high-grain rations, careful attention to processing is necessary to minimize problems associated with acidosis and bloat.

Research with vomitoxin-infested barley for beef cattle indicates that vomitoxin is not a concern in barley-based diets for beef cattle. Vomitoxin level should not be used to discount the value of barley in beef cattle diets.

Use of barley in diets for beef cattle should be dictated by economics. In most cases, barley is a cost effective substitute for corn.

Literature Cited

Anderson, V.L., E.W. Boland, and H.H. Casper. 1995. The effects of vomitoxin (DON) from scab infested barley fed to gestating and lactating heifers. Carrington Research Center Beef Production Field Day. Vol. 18:10-12.

Beauchemin, K.A., S.D.M. Jones, L.M. Rode, and V.J. H. Sewalt. 1997. Effects of fibrolytic enzymes in corn or barley diets on performance and carcass characteristics of feedlot cattle. Can. J. Anim. Sci. 77:645-653.

Beauchemin, K.A., T.A. McAllister, Y. Dong, B.I. Farr, and K.-J. Cheng. 1994. Effects of mastication on digestion of whole cereal grains by cattle. J. Anim. Sci. 72:236-246.

Berthiaume, R., J.G. Buchanan-Smith, O.B. Allen, and D.M. Veira. 1996. Prediction of liveweight gain by growing cattle fed silages of contrasting digestibility, supplemented with or without barley. Can. J. Anim. Sci. 76:113-119.

Bock, B.J., R.T. Brandt, D.L. Harmon, S.J. Anderson, J.K. Elliot, and T.B. Avery. 1991. Mixtures of wheat and high-moisture corn in finishing diets: feedlot performance and in situ rate of starch digestion in steers. J. Anim. Sci. 69:2703-2710.

Boland, E.W., V.L. Anderson, H.H. Casper, P.T. Berg, and D.V. Dhuyvetter. 1994. The effects of increasing vomitoxin (DON) levels from scab infested barley fed to feedlot steers. Carrington Research Center Beef Production Field Day. Vol. 17:34-38.

Boss, D.L., and J.G.P. Bowman. 1996a. Barley varieties for finishing steers: I. Feedlot performance, in vivo diet digestion, and carcass characteristics. J. Anim. Sci. 74:1967-1972.

Boss, D.L., and J.G.P. Bowman. 1996b. Barley varieties for finishing steers: II. Ruminal characteristics and rate, site, and extent of digestion. J. Anim. Sci. 74:1973-1981.

Bradshaw, W.L., D.D. Hinman, R.C. Bull, and D.O. Everson. 1992. Steptoe vs. Klages barley varieties and processing methods on feedlot steer nutrient digestibility, carcass characteristics, and performance. J. Anim. Sci. 70:134.

Bradshaw, W.L., D.D. Hinman, R.C. Bull, D.O. Everson, and S.J. Sorenson. 1996. Effects of barley variety and processing methods on feedlot steer performance and carcass characteristics. J. Anim. Sci. 74:18-24.

Brake, A.C., A.L. Goetsch, L.A. Forster, Jr., and K.M. Landis. 1989. Feed intake, digestion, and digesta characteristics of cattle fed bermudagrass or orchardgrass alone or with ground barley or corn. J. Anim. Sci. 67:3425-3436.

Carey, D.A., J.S. Caton, and M. Biondini. 1993. Influence of energy source on forage intake, digestibility, in situ forage degradation, and ruminal fermentation in beef steers fed medium quality brome hay. J. Anim. Sci. 71:2260-2269.

Cochran, R.C., D.C. Adams, P.O. Currie, and B.W. Knapp. 1986. Cubed alfalfa hay or cottonseed meal-barley as a supplement for beef cows grazing fall-winter range. J. Range Manage. 39:361-364.

Combs, J.J. and D.D. Hinman. 1985. Energy requirements for rolling barley. Univ. of Idaho SW Idaho R/E Ctr. Progress. Rep. No. 232.

Combs, J.J. and D.D. Hinman. 1988. Use of high moisture ear corn, corn and barley in beef cattle finish rations. Proc. West. Sec. Am. Soc. Anim. Sci. 39:402-405.

Combs, J.J. and D.D. Hinman. 1989. Effect of dry-rolled and tempered-rolled barley or wheat on feedlot cattle performance. Proc. West. Sec. Am. Soc. Anim. Sci. 40:373-376.

Criswell, R.J., M.L. Nelson, H.H. Westburg, and S.M. Parish. 1996. Effects of tallow on energy metabolism of wethers fed barley finishing diets. Proc. West. Sec. Amer. Soc. Anim. Sci. 47:261-263.

DiCostanzo, A. J.D. Meiske, M. Murphy, R. Epley, L. Felice, L. Johnston, and H. Chester-Jones. 1995. Effects of feeding vomitoxin-contaminated barley on performance of feedlot steers. Minnesota Cattle Feeders Report. B-418:6-8.

Duncan, R.W., J.R. Males, M.L. Nelson, and E.L. Martin. 1991. Corn and barley mixtures in finishing steer diets containing potato process residue. J. Prod. Agric. 4:426-432.

Economides, S., A. Koumas, E. Georghiades, and M. Hadjipanayiotou. 1990. The effect of barley-sorghum grain processing and form of concentrate mixture on the performance of lambs, kids, and calves. Anim. Feed Sci. Tech. 31:105-116.

Engstrom, D.F., G.W. Mathison, and L.A. Goonewardene. 1992. Effect of ß-glucan, starch, and fibre content and steam vs. dry rolling of barley grain on its degradability and utilization by steers. Anim. Feed Sci. Tech. 37:33-46.

Feng, P., C.W. Hunt, G.T. Pritchard, and S.M. Parish. 1995. Effect of barley variety and dietary barley content on digestive function in beef steers fed grass hay-based diets. J. Anim. Sci. 73:3476-3484.

Flipot, P.M., V. Girard, M. Bernier-Cardou, and H.V. Petit. 1992. Digestibility and performance of dairy bulls fed corn and grass silages with various sequences and levels of barley. Can. J. Anim. Sci. 72:61-69.

Fredrickson, E.L., M.L. Galyean, R.G. Betty, and A.U. Cheema. 1993. Effects of four cereal grains on intake and ruminal digestion of harvested forages by beef steers. Anim. Feed Sci. Tech. 40:93-107.

Galloway, D.L., Sr., A.L. Goetsch, L.A. Forster, Jr., A.C. Brake, and Z.B. Johnson. 1993. Digestion, feed intake, and live weight gain by cattle consuming bermudagrass and supplemented with different grains. J. Anim. Sci. 71:1288-1297.

Gray, D.G. and G.F. Stallknecht. 1988. Barley versus corn in finishing diets for beef calves. Proc. West. Sec. Am. Soc. Anim. Sci. 39:322-323.

Grimson, R.E., R.D. Weisenburger, J.A. Basarab, and R.P. Stilborn. 1987. Effects of barley volume-weight and processing method on feedlot performance of finishing steers. Can. J. Anim. Sci. 67:43-53.

Haugen, R.G., T.C. Faller, E.W. Boland, H.H. Casper, and D.V. Dhuyvetter. 1996. The effects of vomitoxin (DON) from scab infested barley on reproductive performance when fed to ewe lambs. Proc. 37th Annual Western Dakota Sheep Day. pp.9-12.

Hepton, J.R., C.W. Hunt, T.C. Griggs, G.T. Pritchard, and P. Feng. 1995. Composition and ruminal fermentability of barley grain, hulls, and straw as affected by irrigation level, planting date, and variety. Proc. West. Sec. Amer. Soc. Anim. Sci. 46:448-451.

Hinman, D.D. 1978. Influence of barley test weight on beef cattle performance. Proc. West. Sec. Amer. Soc. Anim. Sci. 29:390-391.

Hinman, D.D. and J.J. Combs. 1983. Tempered versus dry-rolled barley rations for feedlot steers. Proc. West. Sec. Amer. Soc. Anim. Sci. 34:306-307.

Hinman, D.D. and J.J. Combs. 1984. Performance of steers fed either dry-rolled, temper-rolled, or steam-rolled barley based grower and finishing rations. Proc. West. Sec. Amer. Soc. Anim. Sci. 35:246-248.

Hinman, D.D. and S.J. Sorenson. 1994. Comparison of different tempering times for barley based feedlot diets and their influence on animal performance, carcass characteristics, diet digestibility, and in vitro barley digestibility. Proc. West. Sec. Amer. Soc. Anim. Sci. 45:309-312.

Jacobs, J.L., R.J. Morris, and J. Zorrilla-Rios. 1995. Effect of ensiling whole barley grain with pasture on silage quality and effluent production and performance of growing cattle. Aust. J. Exp. Agr. 35:731-738.

Jones, D.I.H., R. Jones, and G. Moseley. 1990. Effect of incorporating rolled barley in autumn-cut ryegrass silage on effluent production, silage fermentation, and cattle performance. J. Agr. Sci. 115:399-408.

Kercher, C.J., D. Bergener, and R. Jones. 1986. Barley varieties, high moisture corn, vs. dry corn and single or multiple hormone implants for finishing beef steers. Wyo. Agric. Exp. Stn. Bull. pp.3-8.

Krause, M. K.A. Beauchemin, L.M. Rode, B.I. Farr, and P. Nørgaard. 1998. Fibrolytic enzyme treatment of barley grain and source of forage in high-grain diets fed to growing cattle. J. Anim. Sci. 76:2912-2920.

Kreikemeier, R.A. Stock, D.R. Brink, and R.A. Britton. 1987. Feeding combinations of dry corn and wheat to finishing lambs and cattle. J. Anim. Sci. 65:1647-1654.

Leventini, M.W., C.W. Hunt, R.E. Roffler, and D.G. Casebolt. 1990. Effect of dietary level of barley-based supplements and ruminal buffer on digestion and growth by beef cattle. J. Anim. Sci. 68:4334-4344.

Malcom, K.J. and H.E. Kiesling. 1993. Dry matter disappearance and gelatinization of grains as influenced by processing and conditioning. Anim. Sci. Feed Tech. 40:321-330.

Mathison, G.W., D.F. Engstrom, R. Soofi-Siawash, and D. Gibb. 1997. Effects of tempering and degree of processing of barley grain on the performance of bulls in the feedlot. Can. J. Anim. Sci. 77:421-429.

Mathison, G.W., D.F. Engstrom, and D.D. Macleod. 1991a. Effect of feeding whole and rolled barley to steers in the morning or afternoon in diets containing differing proportions of hay and grain. Anim. Prod. 53:321-330.

Mathison, G.W., R. Hironaka, B.K. Kerrigan, I.Vlach, I.P. Milligan, and R.D. Weisengurger. 1991b. Rate of starch degradation, apparent digestibility, and rate and efficiency of steer gain as influenced by barley grain volume-weight and processing method. Can. J. Anim. Sci. 71:867-878.

Momont, P.A., D.D. Hinman, M.V. Boggness, C.W. Hunt, and R.C. Bull. 1994. Effects of energy supplementation of ammoniated barley straw on performance of cull beef cows. J. Prod. Agr. 7:437-440.

NRC. 1996. Nutrient requirements of beef cattle (Seventh Ed.). National Academy Press, Washington, D.C.

Nelson, M.L., T. Schwegel, and R.J. Criswell. 1998. Digestibility of tallow fatty acids by wethers fed a barley diet. J. Anim. Sci. 76 (Suppl. 1):301.

Ovenell-Roy, K.H., M.L. Nelson, J.A. Froseth, S.M. Parish, and E.L. Martin. 1998a. Variation in chemical composition and nutritional quality among barley cultivars for ruminants. 1. Steer finishing performance, diet digestibilities and carcass characteristics. Can. J. Anim. Sci. 78: 369-375.

Ovenell-Roy, K.H., M.L. Nelson, J.A. Froseth, and S.M. Parish. 1998b. Variation in chemical composition and nutritional quality among barley cultivars for ruminants. 2. Digestion, ruminal characteristics, and in situ disappearance kinetics. Can. J. Anim. Sci. 78:377-388.

Owens, F.N., D.S. Secrist, W.J. Hill, and D.R. Gill. 1997. The effect of grain source and grain processing on performance of feedlot cattle: a review. J. Anim. Sci. 75:868-879.

Staigmiller, R.B. and D.C. Adams. 1989. Free-choice grain and forage for early-weaned beef calves. Nutr. Rep. Intl. 39:1053-1059.

Steen, R.W.J. 1993. A comparison of wheat and barley as supplements to grass silage for finishing beef cattle. Anim. Prod. 56:61-67.

Stock, R.A. and B.A. Britton. 1993. Acidosis in feedlot cattle. In: Scientific update on Rumensin/Tylan for the professional feedlot consultant. Elanco Animal Health, Indianapolis, IN. p. B1.

Stock, R.A., D.R. Brink, B.A. Britton, F.K. Goedeken, M.H. Sindt, K.K. Kreikemeier, M.L. Bauer, and K.K. Smith. 1987. Feeding combinations of high moisture corn and dry rolled grain sorghum to finishing steers. J. Anim. Sci. 65:290-302.

Toland, P.C. 1976. The digestibility of wheat, barley or oat grain fed either whole or rolled at restricted levels with hay to steers. Aust. J. Exp. Agric. and Anim. Husb. 16:71-75.

Ulmer, D.N., J.S. Caton, S.L. Boyles, and D.O. Erickson. 1990. Influence of increasing level of barley supplementation on forage intake, digestibility, and ruminal fermentation in beef steers fed medium quality hay. J. Anim. Sci. 68(Suppl. 1):571 (Abstr.).

Veira, D.M., J.G. Proulx, and J.R. Seoane. 1990. Performance of beef steers fed grass silage with or without supplements of soybean meal, fish meal, and barley. Can. J. Anim. Sci. 70:313-317.

Ward, M.G., D.C. Adams, J.D. Wallace, M.L. Galyean, and B.W. Knapp. 1990a. Supplementation and monensin effects on digesta kinetics I. Cattle grazing summer range. J. Range Manage. 43:378-382.

Ward, M.G., D.C. Adams, J.D. Wallace, M.L. Galyean, and B.W. Knapp. 1990a. Supplementation and monensin effects on digesta kinetics II. Cattle grazing winter range. J. Range Manage. 43:383-386.

Westvig, R.M. 1992. Effects of barley and Aspergillus Oryzae fungal extract (Amaferm) supplementation on utilization of grass hay by beef cattle. M.S. Thesis. North Dakota State University, Fargo.

Windels, H.F., A. DiCostanzo, and R.D. Goodrich. 1995. Effect of deoxynivalenol from barley on performance and health of large frame crossbred steers. Minnesota Cattle Feeders Report B-417:1-5.

Zinn, R.A. 1988. Comparative feeding value of supplemental fat in finishing diets for feedlot steers supplemented with and without monensin. J. Anim. Sci. 66:213-227.

Zinn, R.A. 1989. Influence of level and source of dietary fat on its comparative feeding value in finishing diets for steers: feedlot cattle growth and performance. J. Anim. Sci. 67:1029-1037.

Zinn, R.A. 1993. Influence of processing on the comparative feeding value of barley for feedlot cattle. J. Anim. Sci. 71:3-10.

Zinn, R.A. and R. Barajas. 1997. Influence of flake density on the comparative feeding value of a barley-corn blend for feedlot cattle. J. Anim. Sci. 75:904-909.

Zinn, R.A., M. Montaño, and Y. Shen. 1996. Comparative feeding value of hulless vs covered barley for feedlot cattle. J. Anim. Sci. 74:1187-1193.

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