Corn compared to barley in feedlot diets

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Abstract

Corn is higher in energy but considerably lower in protein than barley. Although corn contains more energy, its starch is less digestible unless it is steam flaked. Reduced ruminal digestion of the starch in corn typically results in higher intakes, often higher gains, but very similar feed efficiency. Considering these differences and the cost of protein supplementation, the value of corn is about 98% the value of barley unless other higher protein feeds (i.e. millrun, corn gluten pellets, wheat) are available to feed with the corn. Differences in feeding value of different barley varieties likely explains much of the inconsistencies in research that has compared dry-rolled barley to dry-rolled corn.

Introduction

Dry conditions throughout Western Canada the previous couple of years resulted in reduced barley yields and increased prices. For the first time in Alberta cattle feeder's memories, corn was a viable alternative to barley in feedlot diets. Now with an established infrastructure for getting corn into the area, it can be easier to access a consistent supply of corn than barley. Enthusiasm is further increased when people look at book values of the energy content of the two grains. Corn contains at least 15% more starch, and depending on processing and which measurement of energy is used, is estimated to be 5 - 10% higher in energy than barley. However, it is also considerably lower in protein than barley and the extra protein required can be alarming to people that have historically supplemented very little with barley based diets.

Energy (grains) is the primary expense in feedlot production. The Western Canadian feedlot industry has grown and developed using barley, sometimes wheat, and occasionally rye as the primary energy sources in finishing diets. Feedlot managers have gotten proficient at feeding these grains that are considered challenging by our Southern neighbors. The past 18 months experience with feeding corn has been confounded by some wet weather and poor pen conditions so many people are still not clear what the true value of corn is relative to barley.

Compared to barley, what is the energy content of corn?

If the net energy values provided by NRC (1996) (Table 1) are used to predict performance, cattle fed corn should gain about 0.25 lb more each day and require about 0.5 lb less feed to get 1 pound of gain. These are significant improvements in performance that would lower costs of gain by about 4½ cents per pound if there were no other expenses to feeding corn. However, these differences are not always observed in feeding trials and energy values for dry rolled corn may be over estimated (Zinn et al., 2002). Research has been inconclusive when these grains are compared in feeding trials. For example, when Oklahoma researchers summarized research of feedlot trials utilizing barley or corn, barley fed cattle (14 trials; 819 head) had essentially identical intakes, gains, and efficiencies as cattle fed corn (419 trials; 16,228 head). However, caution should be used interpreting these numbers as they were not direct comparisons between the grains and results are confounded by differences in processing between trials. Trials that have directly compared the grains have been inconsistent. Of the 10 trials found that compared the grains, 6 (3 of which were statistically significant) found higher intakes, and 8 (3 of which was statistically significant) found higher gains for cattle fed corn (Table 2). When only trials were considered in which grains were dry rolled, small differences were apparent with corn fed cattle having higher intakes and feed:gain ratios. There have been exactly as many positive as negative responses in feed efficiency when corn was compared to barley. The bottom line is, that considering the theoretical difference in energy levels between corn and barley, performance advantages have been disappointingly inconsistent. Based on performance results, NRC (1996) considerably under estimates the energy value of barley (Owens et al., 1997) but may over estimate the energy value of dry-rolled corn (Zinn et al., 2002). Generally, cattle fed dry-rolled corn may have higher intakes, slightly higher gains, but likely no advantage in feed efficiency compared to cattle fed barley. Differences in performance due to barley varieties (Ovenell et al., 1993; Boss and Bowman, 1996) likely contribute to observed inconsistencies when the grains are compared.

Table 1. Analysis of barley and corn (DM basis)

	Barley	Corn
Dry matter, %	88.0	88.0
Protein	12.5	9.0
Starch	64.3	75.7
Fat	2.1	4.3
ADF, %	7	3
NDF, %	19.0	9.0
NEm, Mcal/kg	2.06	2.18
NEg, Mcal/kg	1.4	1.5
Rumen degradable, % of total		
Starch	90	62
Protein	91	70

Summarized from NRC (1996), Suilemiman, 1995, Nocek and Tamminga, 1991, Hill and Utley, 1989, and Herrera-Saldana et al., 1990.

What are some of the physical differences between corn and barley?

The potential discrepancy between performance and estimated energy values of the grains can be explained in part by potential differences in digestibility due to differences in the kernel structure. The outer structures of corn (pericarp) and barley (husk) are both very resistant to microbial digestion and must be cracked to allow access to microbes and digestion of the starch. With the larger kernels of corn, much of this will occur simply through chewing. The smaller kernels of barley will more easily be swallowed whole and go through the rumen with little or no digestion. Consequently, the digestion of barley (and to a much lesser extent corn) is improved with processing as it enables microbes to gain access to the starch in the endosperm.

Within the endosperm cells of both grains, starch granules are surrounded by a matrix of protein which must be penetrated or removed (either by digestion or processing) to enable the microbes to gain access to and digest the starch. Unlike barley, the endosperm in corn has two distinct regions, the vitreous endosperm region (higher in flint corn) and the floury endosperm region. Whereas starch in the floury endosperm is readily digested after dry-rolling, the starch in the vitreous endosperm region is surrounded by protein that is extremely resistant to microbial invasion and digestion and consequently the protein and starch in this region of the endosperm often gets through the rumen undigested. Obviously, if this bypass starch and protein is not digested in the small intestine, the overall digestibility of the corn will decrease. More severe processing procedures such as steam flaking are required to breakdown the protein matrix in the vitreous endosperm and make the starch available to rumen microbes. In contrast, the protein in barley is readily digested by rumen microbes, access to starch is not limited and as a result over 90% of the starch in barley is usually digested in the rumen.

How much can we increase digestibility of corn through processing?

Dry rolling can increase the energy available from barley by at least 15%. Further improvements with steam-rolling are moderate. According to research summarized by the NRC, there are no advantages to grinding corn. As well, an extensive summary (Owens et al., 1997) found energy content to be slightly higher in whole than in dry-rolled corn. That there are no advantages to dry rolling corn is a little hard to understand given that it does reduce particle size and thereby increases area exposed to digestive enzymes. The bottom line is that benefits to dry rolling corn are small.

It is estimated that steam flaking (more aggressive than steam rolling - not practiced in Western Canada) corn on the other hand will increase energy available from corn by at least 8% (NRC, 1996) and possibly as high as 18% (Zinn et al., 2002) above feeding it whole. Storing high moisture corn will also help break down the protein matrix thereby increasing energy digestibility.

Although the decision to roll barley is an obvious one, feedlot managers should carefully consider whether it is worth rolling their corn. If you use just NRC values to make that decision, you won't be rolling. However, due to the increased opportunities for digestion, some people (including ourselves) find this a little hard to believe. Small improvements in the utilization of energy (i.e. 2% - 3%) as a result of rolling would likely not be detected in smaller research experiments that use a limited number of animals, but this small improvement could represent a significant economic return under larger commercial conditions.

What are the differences in protein between the grains that should be considered?

The most important role of protein for cattle is to feed the microbes in the rumen. A healthy microbial population will not only provide most of the required protein to the calf, but will digest most of the energy in the feed. In other words, if we short change the bugs, we may not get all of the energy out of the feed.

As already mentioned, corn is not only lower in protein than barley, but it's protein is more resistant to digestion in the rumen so it provides considerably less protein (nitrogen and amino acids) to the rumen microbes. Performance will be reduced if protein is not added to high corn diets. The common practice in the US of adding 1% urea to corn based finishing diets brings crude protein levels up to about the same level of barley protein. Research at the Lethbridge Research Centre (Beauchemin et al., unpublished) verifies that added protein through urea enhances performance, and that performance can further be improved by supplementing natural protein (Table 3). Similar results were found by Milton et al., (1997).

Based on book values and confirmed by samples obtained in 2001 to 2003 in Southern Alberta, corn averages at least 3 percentage points lower in protein than barley. In a finishing diet that is 85% grain and 5% supplement (dry matter basis; 17 times as much grain as supplement), each percentage point reduction in protein of the grain requires a 17 percentage point increase in protein of the supplement. So if you want to maintain the same feeding rate of the supplement and the same crude protein level in the diet, you will need to increase the protein level in the supplement by 17 x 3 = 51%! If you were feeding a 10% supplement before, this means feeding a 61% supplement now. Obtaining this level will require a considerable amount of non-protein nitrogen (urea). If you use a pelleted supplement and you plan on maximizing urea use, you are likely going to have to reduce the protein level and increase the feeding rate in order to have a product that flows in your bins (supplements with high urea have a tendency to bridge in bins). The amount of extra protein required can be greatly reduced by feeding other grains or byproducts that are higher in protein.

Obviously, this extra supplementation does not come free and extra costs must be considered when deciding whether corn is worth feeding or not. A very rough thumb rule is that a 1 percentage point increase in protein from urea in the supplement will cost an additional $1.20/tonne. In other words, increasing protein in the supplement (from urea) from 10% to 20% will cost in the neighborhood of $12/tonne. Natural proteins cost at least 5 times this much. If high protein by-products (i.e. millrun, malt sprouts, corn gluten pellets) are an economical source of energy and protein, they will help reduced protein costs and thereby increase the value of corn. However, when the price of barley is climbing (such as when corn might be economical), cattlemen start shopping for options resulting in the price of by-products typically climbing faster than the price of grains. Do your homework before assuming the by-products are a good buy at this time.

Table 3. Summary of finishing trials comparing barley to corn in feedlot diets

				Corn							**Barley**						
Reference	Days	Head	N	process	DMI[z], kg	ADG[y], kg	F/G[x]	BF[w], mm	QG[v]	DP[u]	Process	DMI[z], Kg	ADG[y], kg	F/G[x]	BF[w], mm	QG[v]	DP[u]
1	103-145	56	28	SR	9.31[b]	1.29[b]	7.35[b]	10.7	8.5	60.5	SR	9.79[a]	1.45[a]	6.85[a]	10.8	8.4	60.1
2	168	80	4	DR	10.0[a]	1.43[a]	7.36[a]	9.5	NA[t]	58.4	DR	8.20[b]	1.30[b]	6.32[b]	8.7	NA[t]	58.2
3	83, 111	100	5	DR	9.64	1.63	6.07	9.7	4	58.1	DR	9.72	1.61	6.03	10.7	2	59.0
4	109	30	3	NA[t]	9.24	1.40	6.60	10.9	11.9	62.2	NA[t]	9.38	1.37	6.85	11.4	11.9	62.3
5	84	31	8	DR	12.2[a]	1.61	7.90	9.7	305[a]	NA[t]	DR	10.50[b]	1.5	7.07	8.2	282[b]	NA
6	138	288	6	DR	9.72	1.48	6.35	14.8	56.9	57.8	DR	9.41	1.4	6.22	15.6	56.2	57.8
7	130	144	6	DR	8.70	1.47	5.8[a]	9.7	323	NA[t]	DR	8.90	1.4	6.3[b]	9.3	317	NA
8	172	120	20	SR	9.20	1.37	6.70[a]	20.2[a]	2.2	59.5[a]	SR	9.1	1.31	6.99[b]	18.3[b]	2.0	58.9[b]
9	195	120	4	NA[t]	9.83	1.66[a]	5.95	13.7	5.7	62.0	NA[t]	9.47	1.55[b]	6.11	13.0	5.8	61.9
10	84	159	4	whole	10.38[a]	1.51[a]	6.92	NA[t]	73.3[a]	60.4	DR	9.30	1.40[b]	6.67	NA[t]	48.4[b]	59.2
11a	7 (barley) vs 183 (corn) trials			DR	9.45	1.45	6.57	NA[t]	NA[t]	NA[t]	DR	8.96	1.45	6.25	NA[t]	NA[t]	NA[t]
11b	14 (barley vs 419 (corn) trials			All	8.93	1.43	6.32	NA[t]	NA[t]	NA[t]	All	8.77	1.42	6.24	NA[t]	NA[t]	NA[t]

[z]Dry matter intake; [y]Average daily gain; [x]feed (dry matter) consumed / gain; [w]Backfat; [v]Quality grade, higher values indicate more marbling; [u]Dressing percentage.
[t]Information not available
[ab]Within a reference (row), parameters compared between grain sources with different superscripts differ ($P < 0.05$)

References:
1 = Beauchemin et al., 1997; 2 = Boss and Bowman, 1996 (compared corn to Harrington barley. Gunhilde and Medallion was also compared); 3 = Mathison and Engstrom, 1995: 4 = Nichols and Weber, 1988; 5 = Milner et al., 1995; 6 = Beachemin et al., unpublished; 7 = Nelson et al., 2000; 8 = Gibb et al., unpublished; 9 = Windels et al., 1994; 10 = Pritchard and Robins, 1991; 11 = Owens et al., 1997.

Table 3. Performance of cattle fed barley or corn with or without supplemental protein.

Grain	Barley	Corn	Corn	Corn
Supplemental protein			urea	canola meal
Protein level, %	12.5	9.5	12.5	12.5
Initial weight, kg	434	434	434	438
Final weight, kg	628ab	612b	629ab	643a
DM intake, kg	9.41ab	8.97b	9.82a	9.72a
ADG, kg	1.56a	1.32c	1.47b	1.57a
Feed:gain	6.22a	7.09b	6.84b	6.35a

a,b,c = values in the same row with different superscripts differ ($P < 0.05$).

At what price should I start feeding corn?

If energy values are as high for dry rolled corn as NRC indicates they are, we can afford to pay for the extra protein as well as a small premium (~3%) above the price of barley. More realistically, if the difference between dry rolled corn and barley is only ½ as much as NRC indicates, by the time we pay for the extra protein we can only afford to pay about 98% what the price of barley is.

Although there is more energy in corn than barley, it needs to be steam flaked or fermented (stored high moisture) to capitalize on this higher energy level. Until feedlots are set up to do this, we would be a little skeptical of anyone that tries to convince us that corn is a superior grain than barley.

References

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.

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

Boss, D. L., J. G. P. Bowman, and R. M. Brownson. 1994. Effects of barley variety or corn on feedlot performance, carcass characteristics, and diet digestion by steers. Proc. West. Sect., Am. Soc. Anim. Sci. 45:313-316

Herrara-Saldana, R. E., J. T. Huber, and M. H. Poore. 1990. Dry matter, crude protein, and starch degradability of five cereal grains. J. Dairy Sci. 73:2386-2393.

Hill, G. M., and P. R. Utley. 1989. Digestibility, protein metabolism and ruminal degradation of Beagle 82 triticale and Kline barley fed in corn-based diets. J. Anim. Sci. 67:1793-1804

Mathison, G. W. and D. F. Engstrom. 1995. Ad libitum versus restricted feeding of barley- and corn-based feedlot diets. Can. J. Anim. Sci. 75:637-640.

Milner, T. J., J. G. P. Bowman, and B. F. Sowell. 1995. Effects of barley variety or corn on feedlot performance and feeding behavior. Proc. West. Sect., Am. Soc. Anim. Sci. and West Branch Can. Soc. Anim. Sci. 46:539-452

Milton, C. T., R. T. Brandt, Jr., and E. C. Titgemeyer. 1997. Effects of dietary nitrogen source and concentration in high-grain diets on finishing steer performance and nutrient digestion. J. Anim. Sci. 75:2813-2823

Nelson, M. L., J. R. Busboom, J. D. Cronrath, L. Falen, and A. Blankenbaker. 2000. Effects of graded levels of potato by-products in barley- and corn-based beef feedlot diets. I. Feedlot performance, carcass traits, meat composition, and appearance. J. Anim. Sci. 78:1829-1836.

Nichols, W. T. and D. W. Weber. 1988. Wheat versus corn and barley in beef finishing rations. Proc. West. Sect., Am. Soc. Anim. Sci. 39:406-409

Nocek, J. E. and S. Tamminga. 1991. Site of digestion of starch in the gastrointestinal tract of dairy cows and its effect on milk yield and composition. J. Dairy Sci. 74:3598-3629

Ovenell, K. H., M. L. Nelson, J. A. Froseth, S. M. Parish and E. L. Martin. 1993. Feedlot performance, carcass characteristics of steers, and digestibility of diets containing different barley cultivars. Proc., West. Sect. Am. Soc. Anim. Sci. 44:41-419.

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

Pritchard, R. H. and M. A. Robbins. 1991. Substitution of rolled barley for whole shelled corn in finishing diets for steers. South Dakota State University Beef Report 91-7:21-24.

Spicer, L. A., C. B. Theurer, J. Sowe, and T. H. Noon. 1986. Ruminal and post-ruminal utilization of nitrovtgen and starch from sorghum grain-, corn-, and barley- based diets by beef steers. J. Anim. Sci. 62:521-530.

Suileiman, Abdulatif I. H. 1995. Ten year average analysis of Alberta feeds. Alberta Agriculture

Windels, H. F., B. W. Woodward, J. C. Meiske and R. D. Goodrich. 1994. The effect of combined use of trenbolone acetate and estradiol implants on response of large-frame crossbred steers to dietary energy sources. Minnesota Cattle Feeder Report B-410

Zinn, R. A., F. N. Owens, and D. R. Ware. 2002. Flaking corn: processing mechanics, quality standards, and impacts on energy availability and performance of feedlot cattle. J. Anim. Sci. 80: 1145-115