AN INTRODUCTION TO NUTRITIVE ASPECTS OF BARLEY FOR BEEF AND DAIRY CATTLE

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Introduction

Variability in nutritive quality of feed grain is an aspect of feeding management that livestock producers, as well as nutritionists, often conveniently overlook. While the importance of forage quality testing is routine because of the recognized variability in nutritive quality in forages, quality testing of feed grains is much less common. By contrast, a common principle many producers and nutritionists subscribe to is that "corn is corn"; that all sources of corn grain are equal in nutritive value regardless of the genetics or growing environment. Especially in the last twenty years; however, most beef and dairy producers have a heightened realization that barley is tremendously variable in nutritive value, especially its energy content. To a certain degree we have come of age in our understanding of grain quality and realize that feed grains are variable in nutritive characteristic. Further, we recognize that barley is much more variable in nutritive quality than corn, or for that matter, any of the feed grains. Variability in nutritive characteristics in barley creates obvious challenges to avoid inferior barley sources. On the other hand variability of barley quality presents opportunities to identify superior barley sources for improved animal performance. Clearly, conventional reporting of nutritive characteristics (net energy, protein, and minerals) may not be appropriate when pricing barley or formulating barley-containing rations.

The formation of barley commodity commissions in individual states during the last several decades might well be considered the beginning of the era of recognition of barley quality variability. For example, the Idaho Barley Commission was founded in 1988, which marked the beginning of funding for university testing of barley varieties in Idaho (Reynolds et al. 1992). Since that time a wealth of research has confirmed the barley quality variability. In the mid 1990s a USDA-ARS western regional coordinating committee (W-166) was formed to focus on aspects of barley quality. A second-generation coordinating committee (WCC-205) evolved in 1999 from the original effort. Participants of this present-day coordinating committee include barley breeders and animal nutritionists from throughout the northern-most states of the US. Recognizing that an abundance of experimental results on barley quality was available, a

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primary objective of the current coordinating committee is: "to ***educate*** end users about variation in nutritional or feed quality of barley, including research information that has not been previously summarized and disseminated." The following four proceedings articles and their associated presentations at the conference is the first step in accomplishing that objective.

The Problem ….

Except for oats, barley differs from other feed grains in that it has an attached seed hull. The barley hull is extremely fibrous and is of very low digestibility. Hepton et al. (1995) evaluated the effects of barley variety, growing location, planting date, and irrigation levels on composition of barley grain and hulls. Barley sources evaluated ranged from 15.9 to 18.1 percent hull (as a percent of kernel dry matter). Hulls varied between 28.8 and 35.2 percent ruminal degradability (24 hour in situ disappearance). Further, varieties having the greater percent hull also had the hulls that were lower in degradability. Therefore, these varieties had a double negative; they had greater fiber content (and consequently lower starch content) and the fiber was of a lower quality. Clearly, the barley hull adds a dimension of quality that is not a consideration with most other feed grains.

An interesting question asked at this point, is why have we not progressed toward improved sources of barley by now; why do we have less than superior quality barley for feeding to livestock? The answer is not simple but in general is likely because it is difficult to exert control over the two main factors that determine barley quality; growing conditions and genetics. In evaluating over 300 sources of barley from a three-state area, Reynolds et al (1992) reported that variability in chemical composition of barley was largely due to growing location. Aside from irrigation, there are obviously few management strategies that impact the environment in which the barley is grown.

Unfortunately, barley genetics has also been a difficult factor to alter. The US agriculture system is characteristically segregated with regard to phases of production. Barley growers are typically not the end users of barley. Consequently, end users (livestock producers) must provide economic incentives to barley producers to grow barley with superior quality genetics. This has been a difficult system to institute. While superior quality varieties have now been identified, these varieties must be competitive in agronomic traits for growers to produce them. As a specific example, Steptoe is a variety of barley that is quite well adapted to the Pacific Northwest being noted for high yields per acre. For this reason, Steptoe barley continues to be widely grown despite the fact that it

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has been identified as an inferior quality variety (Hepton et al, 1995; Sanford et al., 1997; Ovenell-Roy et al., 1998). It is only recently that Baronesse, a noted superior quality barley variety, has begun to displace Steptoe as it has yields that are competitive with Steptoe.

Despite these obstacles barley quality should be an easy sell to livestock producers for most production scenarios. Consider for example a ration formulated for growing beef cattle that is 60% barley and 40% alfalfa. Using NRC values for net energy-maintenance and net energy-gain (2.12 and 1.45 Mcal per kg, respectively) the producer could expect a gain of 2.6 pounds per day for a 550 pound steer consuming 2.4% of its body weight daily. If, however, the actual energy value of the barley was 10% lower than the NRC value (not an unreasonably lower energy value considering the variability in barley), the same steer would gain only 2.1 pounds per day. The same principle and reduced performance could be expected with lactating dairy cattle. In either application the producer would be obviously disappointed with the barley. This scenario is why many livestock producers are hesitant when purchasing barley and would often prefer to purchase corn except when the price differential is exceptionally wide.

How can barley quality most accurately be measured?

Progress toward improved sources of barley requires fast and accurate methods of predicting energy value. The years of barley quality evaluation have not resulted in a consensus on predictive factors that accurately reflect metabolizable energy. At the center of the controversy has been the accuracy of bulk density (bushel test weight) as a quality indicator. Bulk density remains the most common method of barley quality evaluation and is actually an indirect measure of the chemical composition of barley. Whereas fiber is light and starch is heavy, it is logical that barley having a greater test weight would have a high starch to fiber ratio, and consequently have a greater energy value. Hinman (1978) was one of the first to identify the logical relationship between bulk density and growth performance for finishing beef cattle. Four barley sources ranging from 542 to 657 g/l (42 to 50.9 lbs/bu) were evaluated. As bulk density decreased, CP and ADF increased. These changes in composition as bulk density decreased corresponded to decreased daily gain and a numerical trend for reduced feed efficiency. Later investigations called to question the accuracy of bulk density as an indicator of barley quality. Grimson et al. (1987) and Mathison et al. (1991) both reported a plateau in barley volume-weight above which growth performance did not improve. Boss and Bowman (1996) evaluated three barley varieties and found differences in growth performance when fed in finishing

rations to beef steers; however, performance differences for the barley sources were not associated with differences in bulk density. In fact the barley with the numerically lowest test weight had the greatest calculated NEm and NEg values based on growth performance. Further, differences in starch and fiber content did not correspond to differences in bulk density, which substantially confounded our understanding of barley quality factors.

A number of studies were recently reported from Washington State University that provided a great deal of clarification to barley quality questions. Bulk density was not related to digestibility or growth performance variables, while efficiency of gain appeared to be correlated with fiber and starch content (Ovenell-Roy et al., 1998a and b). Authors concluded that NDF content, NDF digestibility, and digestibility of NDF constituent monomers were primary factors impacting nutritional quality of barley for ruminants. These observations were consistent with the previously cited observations of Hepton et al. (1995) that barley hull and barley fiber have extremely low ruminal degradability.

The logical endpoint of barley quality investigations would be the development of regression equations based on measurable entities to predict the metabolizable energy content of any given source of barley. Recently, Fairbairn et al. (1999) measured DE and ME content of 20 sources of barley (four samples from each of 5 varieties) in growing pigs. The DE and ME content varied among sources by 15.2 percent. The variation in DE content was most closely associated with cell wall carbohydrates with 85 percent of the variation accounted for in the following equation using ADF content only:

DE, kcal/kg, 90% DM = 3,526 – 92.8 (ADF 90% DM basis)

While these energy determinations were made with growing pigs, the results might well be relevant for ruminants. It is logical that the ADF fraction of barley would be largely indigestible in the pig, and therefore an accurate negative index of digestible energy. Whereas the fiber in barley has been established to be resistant to ruminal decay, it is likewise logical that fiber content would be a significant negative index of digestible energy for the ruminant animal.

A recent experiment in our research program evaluated factors associated with the DE content of eight sources of barley fed to beef steers (Sanford et al., 2000). The eight barley sources were selected to represent the most diverse barleys available from among 32 sources of barley. Criteria used to select divergent sources of barley were bulk density and composition (starch, ADF, and crude protein). Barley sources, therefore represented a substantial range in

composition and bulk density (Table 1). It is important to note the lack of relationship between composition (starch and fiber content) and bulk density. Consistent with the principle that density can be predictive of composition, the lightest test weight barley (G) had one of the lowest starch and highest fiber content. However, this relationship does not exist at the opposite end of the bulk density spectrum. That is, the heavy barleys (A, B, and E) are not necessarily the highest starch or the lowest fiber content barleys. The eight sources of barley were fed to 40 beef and digestibility was measured across two experimental periods. Starch, NDF, and ADF were equally predictive of barley DE content, each individually accounting approximately 50 percent of the DE difference in the eight sources of barley. Interestingly, DE prediction was not enhanced by attempts to stepwise increase the number of variables used in the regression equation. Bulk density was not predictive of barley DE content.

Understanding factors associated with nutritive value of barley may be more complex than it appears on the surface. Relationships between chemical composition and digestible energy content are most certainly obscured by the interactions of various other factors including the characteristics of the starchy endosperm, how the grain is processed, other ingredients in the diet, and a host of feeding management practices that impact carbohydrate fermentation. I feel that we can be confident that fiber, most likely NDF, is a potent negative factor affecting barley digestibility, and starch content is similarly a positive factor. Bulk density is probably an accurate index of these chemical constituents at the lower end of the quality spectrum, but it is not accurate in differentiating barleys that are at the upper end of the quality spectrum.

Conclusion

I have identified some of the general challenges in understanding barley quality. The following papers will detail these challenges and describe implications for growth and lactation performance. Also, strategies will be suggested for integrating incentives for barley production and end use; a goal which must be accomplished if we expect progress toward availability of improved sources of barley.

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Table 1. Chemical composition and bulk density of barley sources A through H[a b]

Source	CP	Starch	NDF	ADF	Bulk Density
A	10.2	62.9	18.5	4.6	66.3
B	11.5	60.5	17.8	4.8	66.7
C	9.6	60.0	19.8	5.4	61.4
D	10.4	54.0	25.6	9.6	60.1
E	11.8	57.0	19.0	5.2	70.2
F	14.0	58.0	20.8	5.6	63.7
G	10.7	54.7	24.3	8.8	57.0
H	11.0	57.4	22.0	6.8	59.6

[a] Values are on a DM basis except DM and bulk density.

[b] All values except bulk density expressed as percentages. Bulk density is expressed as kg per dL.

Table 2. Regression equations predicting DE content of barley using chemical composition and bulk density

Variable[a]	Equation	R^2	Prob > F
8 data points			
Starch	DE = 1.4862 + .0386 starch	.535	.039
ADF	DE = 4.0952 - .058 ADF	.499	.050
NDF	DE = 4.5164 - .0377 NDF	.453	.067
Ash	DE = 4.3911 - .2247ash	.133	.375
CP	DE = 3.6208 + .0096 CP	.007	.845
Bulk Density	DE = 3.4968 + .0047 BD	.010	.811
16 data points			
Starch	DE = 1.4549 + .0391 starch	.414	.007
ADF	DE = 4.0901 - .0572 ADF	.312	.025
NDF	DE = 4.4854 - .0362 NDF	.287	.033
Ash	DE = 4.5142 - .2664 ash	.118	.193
CP	DE = 3.5712 + .014 CP	.009	.726
Bulk Density	DE = 3.4968 + .0047 BD	.006	.772

[a] Equations were obtained from 8 different sources of barley, each measured in two experimental periods. Equations from 8 data points were obtained from pooling observations across experimental periods.

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Proceedings of the 36th Annual Pacific Northwest Animal Nutrition Conference. October 9-11, 2001. Boise, ID, pp. 85-92.