Proceedings, The Range Beef Cow Symposium XVII
December 11, 12, and 13, 2001, Casper, WY

THE VALUE OF CORN AS A HAY REPLACEMENT FOR COWS

Cody Wright
Extension Beef Specialist
South Dakota State University

INTRODUCTION

In many western cattle operations, harvested forages have traditionally been considered the most economical feedstuffs for wintering beef cows. However, in certain situations, the nutrient content of standing or harvested forages may be inadequate to meet the nutritional requirements of the beef cow for maintenance, gestation, or lactation. Furthermore, the availability of standing or harvested forages may be limited, especially during drought years and(or) severe winters when the cost of medium- to low-quality forages may reach $80-100 per ton. Feeding corn grain may represent an economically viable alternative in each of these scenarios.

Producers commonly ask "how much corn *can* I feed to my cows?" The answer is quite simple...as much as you like. However, the more difficult question is "how much corn *should* I feed to my cows?" The appropriate answer to this question is entirely dependent on the producer's objectives, the quantity and quality of the available forage, the nutritional status of the cows, and their stage of production. Addition of corn to beef cow diets can be broken down into three systems, supplementation, substitution, and limit feeding. Each system has very different objectives and situations to which they should be applied. Interactions of corn with the intake and utilization of the forage base are predominantly responsible for these differences.

EFFECT OF CORN ADDITION TO FORAGE-BASED DIETS

Most research to date would suggest that the addition of corn to at greater than .25% of body weight results in depressed forage intake and fiber digestibility (Sanson and Clanton, 1989; Sanson et al., 1990). These interactions between corn and forage intake and fiber digestibility will be discussed briefly herein. For more a detailed discussion, readers are referred to the reviews by Bowman and Sanson (1996), Caton and Dhuyvetter (1997), DelCurto et al. (1999), and Horn and McCollum (1987).

Increasing levels of corn in the diet have been associated with reduced intake of harvested forages (Chase and Hibberd, 1987; Sanson and Clanton, 1989) and grazed forages (Horn and McCollum, 1987; Pordomingo et al., 1991). Reductions in forage intake associated with corn supplementation have been attributed to starch (Caton and Dhuyvetter, 1997).

Reductions in forage intake in response to energy supplementation have been termed substitution. Generally, substitution is considered to be a negative phenomenon; however, depending on the availability, quality, and cost of roughage, substitution may represent the most economical means of meeting the nutritional demands of the cowherd. Many different authors have calculated "substitution rates" in an attempt to quantify the interaction of supplements and basal forages. Substitution rate is defined as the change in forage dry matter intake per unit of supplement dry matter fed. For example, if a group of gestating cows were supplemented with 4 lbs of corn, and that supplementation resulted in a 5-lb reduction in forage intake, the substitution rate would be 1.25. Positive substitution rates represent a decrease in forage intake while negative substitution rates indicate increased forage intake as a result of supplementation. Substitution rates may be calculated for the total diet or for the forage alone. Given the interactions between grains and forage discussed previously, it is quite likely that substitution rates for the total diet may be negative (increased total dry matter intake) while the substitution rates for the forage is positive (reduced forage dry matter intake). In a review of 18 studies, Goetsch et al. (1991) calculated that as the level of corn supplementation increased from 0 to 1% of body weight, total dry matter intake increased by 1.2 lb for every 2.2 lbs of corn and forage dry matter intake decreased by 1.0 lb. These data represent substitution rates of -0.54 for total dry matter intake and .46 for forage dry matter intake. Steers consuming bermudagrass or orchardgrass and supplemented with corn at 0.48% of body weight had calculated substitution rates of 0.42 for the bermudagrass and 0.48 for the orchardgrass (Jones et al., 1988). Pordomingo et al. (1991) reported a linear increase in substitution rates from 0.95 to 1.3 as the level of corn in the diet increased from 0 to 0.6% of steer body weight. These steers were grazing native summer pastures with a mean crude protein of 10.5%. Substitution rates may be influenced by many factors including forage quality and availability, type and level of concentrate, and physiological state of the animal (reviewed by Bowman and Sanson, 1996).

Results of research on the effects of energy supplementation on dietary digestibility in ruminants consuming forage-based diets in grazing and pen-fed situations have been variable (Caton and Dhuyvetter, 1997). In cattle grazing summer pastures, corn supplemented at 0.4 or 0.6% of steer body weight decreased forage organic matter digestibility, whereas corn supplemented at 0.2% of body weight actually increased forage organic matter digestibility (Pordomingo et al., 1991). Chase and Hibberd (1987) observed no difference in neutral detergent fiber (NDF) digestibility of low-quality native-grass hay when cows were supplemented with 2.2 lbs of corn; however, as the level of corn increased from 2.2 to 6.6 lbs per day, NDF digestibility decreased by 32.7%. Sanson and Clanton (1989) observed a decrease in NDF disappearance from nylon bags placed in ruminally cannulated steers fed increasing levels of corn. When evaluating the impact of supplemental grains on digestibility, it is essential to discern between forage (fiber) digestibility and total diet digestibility. Forage digestibility only takes into account the percent of the forage that is digested by the rumen microbes and the host animal. In comparison, total diet digestibility refers to the percent of the total diet that is digested. Based on the available literature, corn supplementation likely depresses forage digestibility; however, total diet digestibility may not change or may even increase as the level of corn in the diet increases. Inherent digestibility of the corn is the driving factor for this phenomenon. Since corn is more digestible than forage when evaluated independent of any associative effects, it is reasonable to assume that as the level of corn in the diet increases, total diet digestibility should remain constant or increase accordingly.

The effect of corn supplementation on forage intake and digestibility may be dependent on the level of protein in the diet. In digestion studies, increasing energy at low levels has been observed to decrease low-quality roughage intake and digestibility (DelCurto et al., 1999; Olson et al., 1999); however, at high levels of supplemental protein (greater than 120% of requirements) increasing energy typically has little effect on intake or digestibility of low-quality roughage (DelCurto et al., 1990).

INFLUENCE OF CORN ON ANIMAL PERFORMANCE

The effect of corn supplementation on animal performance has been variable. Rush et al. (1987) reported that cows grazing winter range that were supplemented with 3.5 lbs of ear corn lost more weight than cows supplemented with 2 lbs of 32% protein supplement. Gains of cows that received 3 lbs of ear corn and 1 lb of 40% protein supplement were intermediate. In contrast, during a 60 day drylot period prior to calving, the response to corn supplementation was exactly the opposite. Namminga et al. (1991) supplemented gestating cows grazing winter range with 0.7 lb of crude protein per day while varying the supplement composition from 100% soybean meal to a combination of soybean meal and corn to 100% corn. Cows that received the supplemental corn gained less weight and lost more body condition score than cows supplemented with soybean meal alone. The authors also reported a significant interaction between the level of concentrate in the supplement and the amount of available forage. When forage availability was high, performance was not different between cows that were supplemented with soybean meal alone and those that were supplemented with the combination of corn and soybean meal. However, when forage availability was low, performance decreased as the level of concentrate in the supplement increased. This response is likely a function of the relationship between forage availability and forage quality. Given the opportunity, cattle will generally consume the best quality forages first. Thus, as the amount of available forage declines, the quality of the available forage declines in concert.

Two explanations may account for the observed reduction in cow performance. First, as discussed previously, increasing the level of starch in the diet causes a depression in forage digestibility. Second, while the level of protein in the diet remained constant, the rumen degradability of the protein changed significantly. According to the 1996 NRC for Beef Cattle, 80% of the protein in soybean meal is degradable in the rumen; in contrast, the protein in corn is only 45% degradable. Consequently, even though the level of crude protein in the supplement remained constant, the amount of protein available to support rumen fermentation decreased as the level of corn increased.

The effect of corn supplementation on cow performance was dependent on the level of protein in the diet. In a two-year study, Clanton and Zimmerman (1970) observed significant interactions of protein and energy supplementation on heifer gains. When heifers received supplemental energy at low levels of protein, heifer gains were depressed; however, when energy was supplemented together with high protein levels, gains were increased. These observations are in agreement with those of Pruitt et al. (1993). In a winter grazing trial, gestating beef cows were supplemented with 0.72 of crude protein with either 3.92 or

10.64 Mcal of metabolizable energy or 1.44 lb of crude protein with either 7.78 or 10.91 Mcal of metabolizable energy. As expected, weight gains increased as the level of protein increased. Increasing the level of starch in the supplement failed to further increase gains at the low level of protein; however, when the levels of protein and energy were increased, weight gains increased by 21 lbs.

CORN AS A FORAGE SUPPLEMENT

When forage availability is high, but the quality of the forage is inadequate to meet the nutritional demands of the gestating beef cow, energy supplementation becomes essential. Corn is generally the most economical source of supplemental energy for the cowherd. The primary objective of corn supplementation in this scenario is to increase the energy intake of the cow without sacrificing forage utilization. Supplemental corn will generally correct the energy deficit; however, forage intake and fiber digestibility may be depressed if the level of grain becomes too great.

In order to maintain maximal forage utilization, corn should not be supplemented at more than .25% of body weight. This equates to 2.5 lbs for a 1000 lb cow, 3 lbs for a 1200 lb cow, and 3.5 lbs for a 1400 lb cow. These recommendations are based on whole shelled corn. Ear corn can be supplemented at slightly higher levels; 2.75, 3.25, 3.75 and lbs per day for 1000, 1200, and 1400 lb cows, respectively. Depending on forage quality, and the stage of production and body condition of the cows, supplemental protein may also be required.

CORN AS A FORAGE SUBSTITUTE

In general, when standing or harvested forages are readily available and the quality is adequate to support the cow's nutrient demands, protein is the most beneficial supplemental nutrient. However, when the roughage supply is limited, unavailable, or simply too costly, corn may represent a more economical means to provide energy to the cowherd. Generally corn costs more per ton than forages; however, corn contains more energy per ton than forage. Table 1 illustrates the amount of various hays that can be replaced by 1 lb of corn. Table 2 illustrates the amount that could be paid for different forms of corn in relation to the price of medium-quality hay. It is important to remember that these tables are calculated strictly from the total digestible nutrient (TDN) values for each feed.

As discussed previously, when the level of corn in the diet increases, the digestibility of the forage declines. Quantifying the ramifications of that decrease is extremely difficult. Suffice it to say that forage utilization will be depressed by approximately 10 to 30% as the level of corn increases. Consideration of these effects becomes critical when formulating diets. Calculation of energy intake without correction for associative effects may result in over- or under-estimation of total energy intake. Supplementation of excess protein from a highly degradable source may help reduce or even eliminate these negative responses. However, protein is one of the most expensive nutrients to supplement and increasing protein levels could add significant cost. Supplemental urea may be fed to cows in this situation, but levels should be kept at or below 0.1 lb per day. If the urea is fed together with a high protein natural supplement (greater than 40% crude protein), urea should be fed at less than 10% of the protein equivalent.

There is no easy answer as to what the levels of corn and protein should be in wintering diets. Many factors such as forage quality and availability, the cost of corn, the cost of protein, facilities and managerial abilities should all be considered when deciding what is the best protocol to follow.

LIMIT-FED CORN DIETS

Another alternative feeding strategy that could offer significant cost savings when the availability of standing or harvested forage is limited, would be to offer a limit-fed high-concentrate diet. The major objective of this feeding strategy is to provide enough energy and protein to support maintenance or reach a desired level of weight gain.

While this feeding strategy initially sounds enticing, there are some issues that must be considered. Adoption of this system may be limited to producers with the management skills, facilities, and ability to supply additional labor. Given the high level of concentrate in the diet, more management is required to ensure consistent feed intake and watch for signs of digestive disturbances. Erratic feed consumption could have many negative consequences including acidosis, bloat, and reproductive failure. Producers should also have adequate animal holding facilities (drylot or sacrifice pasture) and the ability to store and deliver feed. With the dramatic reduction in feed intake cattle may appear gaunt and behave as if they are hungry. If the fencing around the holding area is inadequate, this behavior may become problematic. It is also important to resist the temptation to provide additional feed to these animals. Increasing the level of feed above what is required to meet the nutrient demands of the cow could eliminate potential cost savings and cause the cows to become too fleshy. Finally, in order to prevent feed wastage, the diet should be offered in a bunk. Adequate bunk space is also a vital component to maintaining uniform feed consumption. Most guidelines for mature beef cows suggest between 24 and 30 inches of bunk space per head.

Previously, limit-fed high-grain diets have been used in growing systems for backgrounding cattle (Loerch, 1990). However, only recently has the strategy been investigated in gestating beef cows (Loerch, 1996). I In this set of experiments, 29 or 30 cows were fed approximately 11 lbs of whole shelled corn, 2.6 lbs of a pelleted supplement, and 2.2 lbs of first-cutting orchardgrass hay (75% NDF, 10.2% CP) from November to April, while the remaining 41 cows were fed hay free choice. In two of three trials, cows that were fed hay lost more body condition than cows that were limit-fed corn. Overall, cow performance was similar between feeding strategies. Calf birth weights were higher when corn was fed; however, there was no effect on calving difficulty. Calf weaning weights and cow conception rates also tended to be greater in the limit-fed groups. Assuming that corn was priced at $2.00/bushel, the breakeven price for hay would be $44/ton. Said another way, if hay could not be purchased for less than $44/ton, limit-feeding a high-corn diet would be economically feasible. Furthermore, the authors calculated that for every $.20/bu increase in the price of corn, the breakeven price for hay would increase by approximately $2.00/ton. In other trials, monensin supplementation numerically increased cow weight gain, even when heifers were fed 7.5% less feed. The authors reported no negative effects on performance, but did observe behavioral signs of hunger in the cows fed the high-corn diet. While the optimal hay intake for cows fed a high-concentrate diet has not been determined, it would be reasonable to assume that increasing the level of hay in the diet would improve the contentment of the cows, albeit at an increased cost (Loerch, 1996).

Tjardes et al. (1998) examined the influence of corn processing on the digestion of limit-fed diets. Cow-calf pairs were fed either free choice alfalfa hay, or limit-fed diets containing either whole corn or cracked corn and alfalfa. Dry matter and organic matter digestibility were greater in the cattle that received processed corn than in those that received whole corn. Cow and calf performance were not different between cattle that were limit-fed corn-hay diets containing either whole or cracked corn, or free choice hay.

O'Neil et al. (1999) compared different concentrate sources in a limit feeding system for developing heifers. Dietary treatments consisted of free choice prairie hay plus a soybean meal-based supplement, a corn-based diet, a wheat middlings/soybean hulls-based diet, and a barley malt sprout-based diet. Heifers fed high-concentrate diets were provided prairie hay at 0.5% of body weight. Monensin was included in all treatments at 200 mg per day. Weight gains were higher in the concentrate-based diets but were not different between the concentrate sources. Cost of gain was lowest for the heifers that were fed the corn-based and barley malt sprout-based diets. Furthermore, there were no reported cases of bloat or acidosis.

Based on these experiments, corn-based diets fed at restricted intakes, may be effectively used to meet the nutritional demands of gestating beef cows. Limit feeding corn appears to be a nutritionally and economically viable alternative to hay during winter months.

DELIVERY METHODS

The effectiveness of supplementation programs in affected by the ability to reduce intake variation and to meet target supplement consumption (Bowman and Sowell, 1997). If cattle consume less than the desired intake, nutrient requirements may not be met. Conversely, if consumption is too high, supplement cost increases, forage intake and digestibility may decline, and cattle may become too fleshy or develop digestive disturbances (i.e. bloat or acidosis). According to a review published by Bowman and Sowell (1997), the proportion of animals not consuming supplement is increased by limited trough space, small supplement allowances, self-fed supplements, neophobia to feed or feed delivery equipment. and group feeding situations. On the other hand, Variation in individual animal consumption is increased by excessive trough space, limited supplement allowance, limit-fed supplements, neophobia to feed and feed delivery equipment, and individual feeding (Bowman and Sowell, 1997). Careful consideration to the space allowed for each animal and the amount of supplement offered may be an important component to effective supplementation

Several options, with wide varieties in cost and effectiveness, exist for delivery of supplement. In many range settings supplements are provided directly on the ground. This feeding method can be cost effective; however, feed wastage, especially with small particle size feeds, may be a concern even on frozen ground. Many feed manufacturers sell high energy cakes or have the capability to make cakes from cereal grains. Depending on cost, inclusion of high-energy feeds into a range cake may be the best option for many ranchers. Providing the supplement in a bunk or in tires will reduce the amount of wastage. Adequate space must be provided for each animal when using either bunks or tires; otherwise, feed intakes may be extremely inconsistent leading to a multitude of problems.

SUMMARY

Using corn as a supplement to or replacement for hay is an economically viable means with which to increase the energy intake of the cowherd. Effective development of the optimum feeding strategy requires careful evaluation of the underlying objectives of adding corn to the diet. Blind supplementation of corn to high-forage diets without consideration of forage quality and quantity, prices of corn and protein sources, and various management factors could result in increased feed costs for beef producers. Dynamic supplementation and substitution strategies could be formulated and adapted to fit into an infinite number of production scenarios.

LITERATURE CITED

Bowman, J. G. P., and B. F. Sowell. 1997. Delivery method and supplement consumption by grazing ruminants: a review. J. Anim. Sci. 75:543.

Bowman, J. G. P., and D. W. Sanson. 1996. Starch- or fiber-based energy supplements for grazing ruminants. In. M. B. Judkins and F. T. McCollum III (Ed.) Proc. 3rd Grazing Livestock Nutrition Conf., Proc. West. Sect. Am. Soc. Anim. Sci. (Suppl. 1):118.

Caton, J. S., and D. V. Dhuyvetter. 1997. Influence of energy supplementation on grazing ruminants: requirements and responses. J. Anim. Sci. 75:533.

Chase, C. C., Jr., and C. A. Hibberd. 1987. Utilization of low-quality native grass hay by beef cows fed increasing quantities of corn grain. J. Anim. Sci. 65:557.

Clanton, D. C., and D. R. Zimmerman. 1970. Symposium on pasture methods for maximum production oin beef cattle: Protein and energy requirements for female beef cattle. J. Anim. Sci. 30:122-132.

DelCurto, T., B. W. Hess, J. E. Huston, and K. C. Olson. 1999. Optimum supplementation strategies for beef cattle consuming low-quality roughages in the western United States. Proc. Am. Soc. Anim. Sci., 1999. Available at: http://www.asas.org/jas/symposia/proceedings/0922. Accessed October 22, 2001.

Del Curto. T., R. C. Cochran, D. L. Harmon, A. A. Beharka, K. A. Jacques, G. Towne, and E. S. Vanzant. 1990. Supplementation of dormant tallgrass-prairie forage: I. Influence of varying supplemental protein and(or) energy levels on forage utilization characteristics in beef steers in confinement. J. Anim. Sci. 68:515.

Goetsch, A. L., Z. B. Johnson, D. L. Galloway, Sr., L. A. Forster, Jr., A. C. Brake, W. Sun, K. M. Landis, M. L. Lagasse, K. L. Hall, and A. L. Jones. 1991. Relationship of body weight, forage composition, and corn supplementation to feed intake and digestion by Holstein steer calves consuming bermudagrass hay ad libitum. J. Anim. Sci. 69:2634.

Horn, G. W., and F. T. McCollum. 1987. Energy supplementation of grazing ruminants. In. M. B. Judkins (Ed.) Proc. Grazing Livestock Nutrition Conf., Jackson, WY. p 125.

Loerch, S. C. 1990. Effects of feeding growing cattle high-concentrate diets at a restricted intake on feedlot performance. J. Anim. Sci. 68:3068.

Loerch, S. C. 1996. Limit-feeding corn as an alternative to hay for gestating beef cows. J. Anim. Sci. 74:1211.

Namminga, M. C., R. J. Pruitt, C. A. Tusler, and P. S. Johnson. 1991. Effects of level of concentrate and forage availability on the performance of beef cows grazing winter range. South Dakota Beef Rep. 91:43.

NRC. 1996. Nutrient Requirements of Beef Cattle (7^{th} Ed.). National Academy Press, Washington, DC.

Olson, K. C., R. C. Cochran, T. J. Jones, E. S. Vanzant, E. C. Titgemeyer, and D. E. Johnson. 1999. Effects of ruminal adminstration of supplemental degradable intake protein and starch on utilization of low-quality warm-season grass hay by beef steers. J. Anim. Sci. 77:1016.

O'Neil, A. D., D. L. Lalman, C. A. Lents, R. P. Wetteman, and D. R. Gill. 1999. Limit feeding concentrate diets to beef heifers as a replacement for hay or pasture. Oklahoma State Univ. Anim. Sci. Res. Rep. 99:85.

Pordomingo, A. J., J. D. Wallace, A. S. Freeman, and M. L. Galyean. 1991. Supplemental corn grain for steers grazing native rangeland during summer. J. Anim. Sci. 69:1678.

Pruitt, R. J., M. C. Namminga, R. H. Haigh, and D. B. Young. 1993. Level of available forage and supplemental protein and energy for cows grazing winter range. South Dakota Beef Rep. 93:4.

Rush, I. G., D. C. Clanton, T. J. Berg, and A. Applegarth. 1987. Ear corn for cows grazing sandhills winter range and fed meadow hay. Nebraska Beef Cattle Report MP52:36.

Sanson, D. W., and D. C. Clanton. 1989. Intake and digestibility of low-quality meadow hay by cattle receiving various levels of whole shelled corn. J. Anim. Sci. 67: 2854.

Sanson, D. W., D. C. Clanton, and I. G. Rush. 1990. Intake and digestion of low-quality meadow hay by steers and performance of cows on native range when fed protein supplements containing various levels of corn. J. Anim. Sci. 68:595.

Tjardes, K. E., D. B. Faulkner, D. D. Buskirk, D. F. Parrett, L. L. Berger, N. R. Merchen, and F. A. Ireland. 1998. The influence of processed corn and supplemental fat on digestion of limit-fed diets and performance of beef cows. J. Anim. Sci. 76:8.

Table 1. Amount of forage that can be replaced by one lb corn.[a]

Grain	Alfalfa Hay (60% TDN[b])	Brome Hay (56% TDN)	Sorghum-Sudan Hay (56% TDN)	Prairie Hay (48% TDN)
Ear Corn (82% TDN)	1.4	1.5	1.5	1.7
Cracked Corn (91% TDN)	1.5	1.6	1.6	1.9
Whole Shelled Corn (88% TDN)	1.5	1.6	1.6	1.8

[a]Values are based on tabular TDN estimates in the Nutrient Requirements of Beef Cattle, Seventh Edition, National Research Council, 1996.
[b]Total digestible nutrients.

Table 2. Comparative value of medium-quality hay (53% TDN[a]) and grain for wintering cows.[b]

Hay ($/ton)	Value of grain per cwt		
	Ear corn (82% TDN)	Cracked corn (91% TDN)	Whole shelled corn (88% TDN)
40	3.09	3.43	3.32
50	3.87	4.29	4.15
60	4.64	5.15	4.98
70	5.42	6.01	5.81
80	6.19	6.87	6.64
90	6.96	7.73	7.47
100	7.74	8.58	8.30
110	8.51	9.44	9.13
120	9.28	10.30	9.96

[a]Total digestible nutrients.
[b]Values are based on tabular TDN estimates in the Nutrient Requirements of Beef Cattle, Seventh Edition, National Research Council, 1996.