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Substituting High-Energy Grains and Byproduct Feeds for Hay in Beef Cow Diets

Shane Gadberry
Associate Professor - Animal Science

Paul Beck
Professor - Animal Science

Ken Coffey
Professor - Animal Science

Diets composed largely of roughages are commonly considered to be most economical for beef cows. Substituting high-energy feeds (HEF, such as grains and certain byproduct feeds) for roughage may be economical when hay and roughages are scarce and prices are high. Drought tends to shift the economics toward feeding HEF as more energy can be transported per ton of feed in this form compared to hay.

Substituting HEF for low-energy feed such as hay becomes economical when cattle can be maintained at the same level of production but at a lower cost. Since HEFs usually cost more per pound than hay, a smaller amount must be fed to be economically substituted for hay in such rations. This will require some system of restricted feeding.

Feeding high-concentrate, low-roughage diets at restricted intakes to gestating beef cows has been successfully conducted at the University of Arkansas Southwest Research and Extension Center and the Livestock and Forestry Research Station.

Feeding Objectives

Pregnant cows should be fed to maintain health and vigor and to support normal growth and development of the fetus. To rebreed successfully, cows should be fed to a moderate body condition (body condition score of 5) by the time of calving.

In maintaining breeding stock, a basic question should be, "How can I provide an **adequate** ration at the **least** possible cost?" To find the answer to this question, a producer needs to know:

- The animal's daily nutritive requirements.
- The nutritive value of common feeds.
- The substitution value of available feeds in relation to nutritive properties and cost.

Nutritive Requirements

Meeting the nutrient requirements of the pregnant cow is the basic underlying objective. This can be done in a number of ways, and economics will normally dictate the feed combinations that should be considered. However, another concern is that the nutrient availability matches the nutrient needs for the cow during the various phases of pregnancy and lactation.

Substituting HEFs for Hay

Table 1 shows the TDN (total digestible nutrient) value of various grains and byproducts compared to prairie, sorghum-sudan, alfalfa and grass (bermudagrass, fescue or a mixture of grasses) hay. By using this table, the approximate feeding value of various HEFs in relation to hay may be determined. For example, on the basis of TDN, corn grain is worth 1.7 times as much as good-quality grass hay, or 1 pound of corn will replace 1.7 pounds of grass hay in a beef cow ration.

Table 2, which is based on TDN value of feeds, shows the price that could be paid for various HEFs in relation to the price of grass hay. For example, if good-quality grass hay costs $50 per ton delivered, you could afford to pay up to $4.25 per hundredweight for corn grain or $3.75 per hundredweight for oats delivered.

Table 1. TDN Value of Various Grains Compared to Prairie, Sorghum-Sudan, Alfalfa and Grass Hay[1]

Grain/Byproduct	TDN	Amount of Hay That Can Be Replaced by 1 Pound of Grain			
		Prairie (47% TDN)	Sorghum-Sudan (56% TDN)	Alfalfa (60% TDN)	Grass[2] (53% TDN)
Corn	90	1.9	1.6	1.5	1.7
Barley	84	1.8	1.5	1.4	1.6
Oats	77	1.6	1.4	1.3	1.5
Processed Sorghum, Milo	83	1.8	1.5	1.4	1.6
Processed Wheat	88	1.9	1.6	1.5	1.7
Ear Corn	83	1.8	1.5	1.4	1.6
Soybean Hulls	70	1.5	1.3	1.2	1.3
Corn Gluten Feed	80	1.7	1.4	1.3	1.5
Dried Distillers Grain	88	1.9	1.6	1.5	1.7

[1]TDN content of grains and hays is on a dry-matter basis. [2]Grass hay is bermudagrass, fescue or a mixture of grasses.

If grain can be bought for less than the value indicated in Table 2, the substitution of grain for part of the roughage in the ration of beef cows would be economical.

The value of the various HEFs in relation to the price of prairie, sorghum-sudan or alfalfa hay can be calculated from the relative energy values shown in Table 1. Multiply the price per ton of the hay by the relative energy value of the HEF and then divide by 20 to convert to a hundredweight basis. For example, if prairie hay costs $50 per ton, the amount you could afford to pay for corn would be $50/20 x 1.9 = $4.75/cwt.

Substitution Guide

In estimating total feed needed, the approximate amount of the HEF required to replace a ton of prairie, sorghum-sudan, alfalfa or grass hay is shown in Table 3. Substitution can be accomplished by either feeding high rates of HEF, which will lower free-choice hay intake, or taking a total mixed ration (TMR) approach and limit feeding the TMR to meet maintenance requirement. The non-TMR substitution method requires adequate protection of hay using ring protectors to minimize waste. In addition, time should be limited to hay to minimize waste and unnecessary intake. Unfortunately, with this method it is more difficult to control energy intake. The TMR approach permits the greatest control over energy intake by limit feeding and can potentially lower hay waste. The challenge to TMR is that most producers are not set up with hay grinding capabilities, requiring them to resort to cottonseed hulls or gin trash for roughage. Rumensin is approved for mature beef cattle, and adding this ionophore to the diet may help reduce the chances of digestive problems occurring.

Adapting to High-Grain Rations

Acidosis, bloat and founder are always a risk when high-grain rations are fed to ruminants. Grain SHOULD NOT be substituted for hay rapidly. To avoid digestive problems, start cattle on grain gradually. It usually takes cattle two to three weeks

Table 2. Comparative Value of Grass Hay* and Grain for Wintering Cows

Hay $/ton	Value of Grain/Byproduct, $/cwt								
	Corn	Barley	Oats	Processed Sorghum	Processed Wheat	Ear Corn	Soybean Hulls	Corn Gluten Feed	Distillers Grains
30	2.55	2.40	2.25	2.40	2.55	2.40	1.95	2.25	2.55
40	3.40	3.20	3.00	3.20	3.40	3.20	2.60	3.00	3.40
50	4.25	4.00	3.75	4.00	4.25	4.00	3.25	3.75	4.25
60	5.10	4.80	4.50	4.80	5.10	4.80	3.90	4.50	5.10
70	5.95	5.60	5.25	5.60	5.95	5.60	4.55	5.25	5.95
80	6.80	6.40	6.00	6.40	6.80	6.40	5.20	6.00	6.80
90	7.65	7.20	6.75	7.20	7.65	7.20	5.85	6.75	7.65
100	8.50	8.00	7.50	8.00	8.50	8.00	6.50	7.50	8.50

*Grass hay is bermudagrass, fescue or a mixture of grasses which contain 53 percent TDN on a dry-matter basis.

Table 3. The Amount of Various Grains/ Byproducts Required to Replace 1 Ton of Prairie, Sorghum-Sudan, Alfalfa or Grass Hay

	Grain Needed to Replace 1 Ton of Hay			
	Prairie	Sorghum-Sudan	Alfalfa	Grass*
Corn, lb	1052	1250	1333	1176
Barley, lb	1111	1333	1428	1250
Oats, lb	1250	1428	1538	1333
Processed Sorghum, lb	1111	1333	1428	1250
Processed Wheat, lb	1052	1250	1333	1176
Ear Corn, lb	1111	1333	1428	1250
Soybean Hulls, lb	1333	1600	1667	1538
Corn Gluten Feed, lb	1176	1429	1538	1333
Distillers Grains, lb	1052	1250	1333	1176

*Grass hay is bermudagrass, fescue or a mixture of grasses which contain 53 percent TDN on a dry-matter basis.

to adapt to a high-grain diet. One method used at the University of Arkansas for transitioning cattle from a forage-based diet to a high-concentrate TMR diet was to place hay in ring feeders, then starting at approximately 1% BW, increase the mixed feed portion every few days until the cattle are completely transitioned over to the high-concentrate total mixed ration. A minimum roughage level of 0.5% body weight in the total mixed ration is needed to maintain rumen health and prevent digestive upset. Coarsely chopped hay, cottonseed hulls or gin trash effectively stimulate rumination. Ground rice hulls or peanut hulls may work well for moderating dietary energy, but these are not as effective at stimulating the rumen due to their small particle size.

Table 4 presents TDN requirements during late pregnancy (11 months since calving), the amount of TDN supplied by hay allowances, and the amount of corn needed to make up the deficit.

Because of possible digestive problems, it is suggested that wheat make up less than one-half of the grain portion fed and that processing the wheat to a flour particle size be avoided. If wheat is to be used, it might be mixed with oats, barley or ground ear corn. Unless the price of the grain dictates otherwise, the use of grains with "built-in roughage" such as barley, oats and ear corn is advisable. These grains will likely perform most satisfactorily over a longer period of time and be less apt to cause feeding problems.

Due to their competitive price, byproduct feedstuffs such as soybean hulls, corn gluten feed and distillers dried grains should also be considered when sourcing a substitute. Byproduct feedstuffs can be a safer substitute because much of their energy comes from digestible fiber instead of starch. In addition, protein requirements are more easily met with these byproducts compared to grains. Research has demonstrated these byproducts can be used for hay substitution.

Additional concerns with transitioning from a high-forage to low-forage diet then back to a high-forage diet is how quickly the digestive system adjusts to the reintroduction of high-forage diets. A ruminal digestion study conducted at the University of Arkansas with limit-fed diets based on soybean hulls and distillers dried grains indicated that the digestive system re-adapts quickly to high-forage diets following limit feeding with these two feedstuffs. In most cases, full recovery was estimated to occur within two weeks. Therefore, adverse carryover effects following limit feeding with these two byproducts should not be a concern.

Cattle being limit-fed will often continue to act hungry despite their nutrient requirements being met. Always monitor body condition and adjust feeding rate as needed to maintain cows in moderate body condition.

Protein Considerations

The comparative values of the various HEFs as shown in Tables 1 to 3 are based on estimated TDN values alone. Differences in protein content of feeds have not been considered. The higher protein grains (barley, oats and wheat) and byproducts (corn gluten feed and distillers grains) would be worth slightly more than is indicated in Table 2, especially if they are fed to younger stock which require more protein in the diet.

In some cases, especially with nursing cows, protein requirements are greater than the amount supplied by the HEF and hay. Therefore, the amount of protein in the hay and HEF should be determined, as well as the amount of limit feeding that is occurring. If the HEF and hay fail to meet the protein requirement when limit-fed, a protein source such as cottonseed meal should be substituted for a portion of the grain to meet the protein needs of the animals, or a high-protein feed such as corn gluten feed or distilled grains added instead of whole grains.

Table 5 shows the calculated amount of cottonseed meal to add to the hay and corn to achieve the protein requirement. Calculating the crude protein needed can be accomplished by examining the total protein of the hay plus grain. If using a high-protein meal, going back and rebalancing energy may not be necessary. In the Table 5 example, the final mix has an energy supply that is slightly above maintenance requirement. If a more moderate protein source is chosen, using a spreadsheet to change the proportion of grain and protein while keeping forage, protein and energy targets constant will provide more accurate estimates of feed amounts needed.

How to Feed HEFs

Preparation for feeding HEFs is something that should be considered. When bunk feeding, grains and byproducts could be fed whole, except sorghum (milo) and wheat which will be more digestible when rolled or ground. If vitamins, minerals and high-protein feedstuffs are added to the HEF portion, HEFs may

Table 4. Amount of Corn Required to Meet the TDN Deficit When Hay DM Is Fed at 0.5% of Body Weight Daily to Mature, Gestating Cows (11 Months Since Calving)

Body Weight Lb	TDN Requirement Lb/Day	TDN Supplied by Hay[a] Dry-Matter Basis	TDN Deficit Lb Dry Matter	Corn Required[b] Lb Dry Matter	Total Diet Intake Lb As-Fed[c]
900	10.1	2.4	7.6	8.4	15.0
1100	11.7	2.9	8.6	9.6	17.5
1300	13.4	3.4	9.7	10.8	20.1

[a]Based on 53% TDN hay dry-matter basis. [b]Based on 90% TDN corn dry-matter basis and 88% dry-matter content.
[c]Total intake at 88% dry matter.

Table 5. Protein Balance and Amount of Cottonseed Meal Needed to Balance the CP Requirement for Cattle Described in Table 4.

Body Weight Lb	CP Requirement Lb/Day	CP Supplied[a] Lb Dry Matter	CP Deficit Lb Dry Matter	Cottonseed Meal Required[b] Lb Dry Matter	Total Diet Intake Lb As-Fed
900	1.5	1.3	0.2	0.4	15.5
1100	1.7	1.5	0.2	0.4	18.0
1300	2.0	1.7	0.3	0.5	20.7

[a]CP of hay at 10% dry-matter basis and corn at 9.8% dry-matter basis. [b]Cottonseed meal at 46% CP dry-matter basis and 88% dry matter.

need to be processed, such as coarsely grinding, to allow a uniform mix and prevent separation during storage and handling. Feed in a manner so each animal has an equal opportunity to eat. Provide at least 30 inches of feed bunk space per cow and try to feed at the same time each day. Sorting the herd into nutritional groups will aid in programming the amount of HEF fed.

Don't Forget Vitamin A and Minerals

There is a good possibility that before spring greenup beef cows may become deficient in vitamin A. Pregnant beef cows (900 to 1,300 pounds) need 25,000 to 35,000 IUs of vitamin A per day before calving and 36,000 to 60,000 IUs per day during lactation. Vitamin A may be included in the protein or energy supplement. A practical way to supplement vitamin A is to include it in the mineral mixture and add the mineral mix to the mixed feed portion.

Subcutaneous injections of vitamin A will bring liver stores up to normal. However, it is advisable to include vitamin A in the mineral or in the feed to ensure adequate amounts for cattle consuming poor-quality hay or high amounts of grain.

Minerals most likely to be deficient in Arkansas forages are salt and the trace minerals zinc, copper, selenium, iodine and cobalt. When animals are maintained on a high-concentrate ration, they can be deficient in calcium and potassium. Calcium can be easily balanced with limestone addition.

Research Results

Research on program-fed, high-concentrate diets has been successfully conducted at the University of Arkansas and elsewhere. At the UofA, gestating beef cows were limit-fed a high corn diet for 87 days from the middle of September through the middle of December. Corn and corn gluten feed were compared as energy sources and cottonseed hulls were used as a roughage source. These high-concentrate options were compared to a standard low-quality hay plus supplement, balanced to meet the herd's protein and energy requirement. Cattle on the hay and supplement diet consumed an average of 26 lbs of dry matter per day, whereas the program-fed cattle consumed 12.3 lbs of dry matter per day. There were no negative effects of using a high-concentrate diet at a restricted intake compared to a high-intake forage diet on cow performance or subsequent cow and calf performance following calving. The positive effect was that cattle were able to maintain performance at half the intake.

During the winter following the drought of 2012, limit feeding gestating cows soybean hulls was evaluated at the University of Arkansas Livestock and Forestry Research Station in Batesville. Cows in the soybean hull group were fed 14 lbs/cow of soybean hulls daily and restricted to 1 hour access to a round hay bale daily. Even though the cattle were restricted to 1-hour hay access, hay disappearance still approached 15 lbs/cow daily. Total hay consumption in the limit-fed soybean hull group was 17 lbs/d less than the total hay consumption of the free-choice access to hay group. Limited hay supplies due to drought resulted in a very high value for hay the following winter. As a result, the feed cost per cow during gestation was $42/cow less when substituting soybean hulls for hay.

Some Suggestions on Substituting Grain for Hay

- Program feeding high-concentrate, low-roughage diets has been shown in research as an economical alternative to high-forage diets. A minimum roughage level of 0.5% of the animal's body weight per day still needs to occur for maintaining rumen health.
- The cattle should receive a balanced ration. It should provide adequate amounts of vitamins and minerals as well as protein and energy.
- Be sure you are equipped to feed high-grain diets. Grain should be fed in a manner so each animal has an equal opportunity to eat, especially when cattle are being limit-fed.
- Figure feed, equipment and labor costs carefully. Be sure there is a cost advantage to the specific program you choose.

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DR. SHANE GADBERRY, associate professor - animal science located in Little Rock, **DR. PAUL BECK**, professor - animal science located at the Southwest Research and Extension Center in Hope, and **DR. KEN COFFEY**, professor - animal science located at the University of Arkansas in Fayetteville, are with the Department of Animal Science of the University of Arkansas System Division of Agriculture.

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