Protein and Energy Supplementation of Crop Residues for Breeding Cattle

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The current drought conditions in many areas of Southern Ohio, West Virginia, and Kentucky are a cause for concern as many people are already feeding next winter's hay supply, causing a severe shortage of hay and an increase in price for that hay still available. The Ohio State University Extension Beef Team has several excellent articles on our web page (http://beef.osu.edu) dealing with various aspects of nutrition and management. However, over the past three weeks, two of the most common questions I've heard are "What can I feed?" and "What's the value of corn stover?". Here are a few thoughts to consider. First, the good news is that we have several sources of alternative sources of high-energy feeds in this area including corn, distillers grains, and pelleted soybean hulls. However, the price of these is going up rapidly, and the time to act is now. Additionally, many producers do not have the facilities to store distillers grains or soybean hulls, or the ability to purchase them in semi-load amounts. This has lead many people to turn to corn stover bales or even soybean stubble bales. Usually, our problem in this part of the country is meeting a cow's or heifer's energy needs, because our grass/legume mixtures are relatively high in protein. With corn stover or soybean stubble, this is NOT the case, and a readily digestible protein source must be used.

To understand the effects of feeding different protein sources, using a variety of feed ingredients as the source of energy, the basics of protein function and ruminal protein degradation must be understood. First, proteins are large molecules that are made of long chains of amino acids linked together in a specific sequence. Proteins serve as enzymes, antibodies, hormones, structural tissues like muscle, and are involved in nearly all cellular activities. Therefore, cattle need adequate protein to grow, mount an immune response, reproduce, maintain a pregnancy, or give birth to and nurse a healthy calf.

Ruminal protein breakdown starts with solubilization of dietary feed proteins in the rumen fluid and subsequent attack by protein degrading enzymes from the rumen bacteria and protozoa. This protein breakdown results in peptides, small chains of less than 30 amino acids, which are soluble in the rumen. The rumen bacteria attach to these peptides, which undergo rapid digestion by rumen bacteria and are progressively broken down to smaller molecular weight peptides and some free amino acids. The peptides and amino acids are then transported into the bacterial cells for hydrolysis to free amino acids. The amino acids are then used for bacterial protein synthesis, or further broken down by the rumen bacteria to ammonia (NH_3), or released into the rumen fluid.

Rumen bacteria need a source of nitrogen (N) to grow. If there is not enough N in the rumen, feed cannot be digested efficiently, because there will not be enough bacteria. This is particularly a problem with low-protein diets, and is made worse if the energy source is relatively indigestible like corn stover or soybean stubble. With forage-based diets, there are usually 1 to 3 billion bacteria per ml of rumen contents, and with a grain-based diet, there are usually 8 to 10 billion bacteria per ml of rumen contents. The main

reason for this difference in bacterial concentration is that bacteria digest feed by attaching to the feed particle. Forages have lignin, an indigestible complex chemical compound that gives strength to plant cell walls. Grains don't have very much lignin, and their rate of digestion is much greater. Think of a blade of grass as a block wall, with the blocks being the digestible carbohydrates (cellulose, hemicellulose, and pectin) and the mortar being the lignin. For the bacteria to attach to the carbohydrate, the lignin bonds must be broken. In the rumen, only rumen fungi, which exist in relatively small numbers compared to bacteria, can break the lignin bond. This is why cattle 'chew their cud'. They are re-chewing forages to break the particle size down so more surface area is available for bacterial attachment and digestion. The more mature the forage, the more lignin it has, and the longer it will take for an animal to digest it or break it down to a small enough size to pass out of the rumen undigested. This is the main reason that chopping forages has been found to increase their digestibility by 30 to 50% in a variety of studies.

Remember that rumen bacteria need a source of nitrogen (N) to grow. The main form of nitrogen (N) utilized by rumen bacteria is ammonia (NH_3) released by breakdown of dietary protein (Van Soest, 1982). In many situations, feeding low levels of urea [$(NH_2)_2CO$] at .4 to .6% of the diet, but NEVER more than 1% of the diet, on a dry matter basis, helps to provide N to the bacteria. In the rumen, urea is converted to ammonia which is either utilized by bacteria or absorbed across the rumen wall, and then transported to the liver where it is converted back to urea. Urea is equivalent to 287% protein, because chemically the protein content of a feed is determined by taking its percent N (46% in the case of urea) and multiplying it by 6.25, because protein contains 16% N (100% ÷ 16% = 6.25). The concentration of ammonia in the blood tends to be lower than in the rumen, and the concentration of urea in the rumen tends to be lower than in the blood, allowing urea to diffuse back into the rumen, creating the potential for a perpetual cycle (Van Soest, 1982). This nitrogen recycling allows ruminal bacteria to adapt to a variety of dietary ingredients ranging from crop residues low in energy and protein to cereal grains high in energy and moderately high in protein. However, if low-protein feeds that are high in lignin like straw, corn stover, and soybean stubble are not chopped and supplemented with appropriate sources of protein, then animal performance will definitely be reduced.

Based upon research, sufficient evidence is available to justify feeding combinations of ruminally available (urea, soybean meal) and ruminally escape (corn gluten meal, distillers dried grains, fishmeal) protein sources in diets comprised of crop residues and low-quality forages. When diets are low in readily available carbohydrates and protein, reduced rumen microbial growth may limit animal production. The amino acids reaching the small intestine in ruminants are supplied by the microbial protein synthesized in the rumen, the undegraded protein, amino acids and peptides from feed which escape rumen degradation, and endogenous secretions. Having ruminally available protein increases digestion and performance, as the rumen microbes may supply 60 to 80 percent of the amino acids that cattle absorb from the small intestine (NRC, 1985).

Feeds Commonly Used for Energy in Beef Cattle Diets*:

	Corn Grain	Corn Silage	Corn Stover	Wheat Straw	Soybean Straw	DDGS	Corn Gluten Feed	Pelleted Soyhulls
DM, %	88	35	85	89	88	92	90	91
CP, %	8.5	8.1	5	3.6	5.2	29	22	12.1
RDP, %	5.8	5.7	na	na	na	21	19	na
TDN, %	90	70	49	41	42	88	83	64
ME, Mcal/kg	3.25	2.53	1.99	1.48	1.52	3.18	3.00	2.31
NEm,, Mcal/kg	2.24	1.63	1.14	0.64	.68	2.18	2.03	1.44
NEg, Mcal/kg	1.55	1.03	0.58	0.11	.15	1.5	1.37	0.86
NDF, %	9.5	45	65	73	70	42	38	62
ADF, %	3.4	28	54	54	54	18	14	50
Lignin, %	0.9	4	7	14	16	4	3	2
Ash, %	1.4	4.5	11.6	7.8	6.4	4.8	7.5	5.1
EE Fat,%	4.2	3.1	2.1	1.8	1.5	10.5	3.2	2.1
Sulfur,%	0.14	0.15	0.11	.19	0.26	.7 - 1.4	0.23	0.09

* The values in this table were taken from a variety of published sources and may differ from the analysis for a particular feed due to differences in maturity, growing season, processing method, or fertilization. The values reported are being used for a reasonable example, but are not absolute. A feed analysis is strongly recommended for diet formulation.

DDGS = Dried Distillers Grains and Solubles; DM= Dry Matter; CP = Crude Protein; RDP = Ruminally Degradable Protein; TDN= Total Digestible Nutrients; ME = Metabolizable Energy; NEm= Net Energy for Maintenance; NEg= Net Energy for Gain; NDF= Neutral Detergent Fiber (cellulose, hemicellulose, and lignin); ADF = Acid Detergent Fiber (cellulose and lignin); EE Fat= Ether Extractable Fat.

Sulfur concentrations are shown, because the upper tolerable limit for sulfur is .4% of the diet in beef cattle (NRC, 1984). Distillers grains have a highly variable sulfur level, so if you are going to be feeding more than 20 to 25% DDGS, having an analyzed sulfur level is highly recommended. Additionally, sulfates in water can be a significant source of sulfur, and the maximum safe concentration of sulfates in drinking water has been proposed to be 2500 ppm (Digesti and Weeth, 1976).

Drought conditions mean that producers may need to do things differently than they have routinely done in order to keep feed prices at somewhat reasonable levels. These include things like selling open females, separating older cows from heifers and 2 year-old females, feeding twice daily, chopping or grinding forage, or feeding alternative sources of energy. It's very important to know the energy and protein levels in your feed, but it's just as important to take into account a feed's digestibility. If corn has a digestibility of 95%, and corn stover has a digestibility of 55%, which one is a better source of energy? Try putting things on a price per pound rather than comparing the bushel price of corn to the bale price of stover. If corn is $3.36 per bushel, it's $.06 per pound ($3.36 ÷ 56 lb = .06/lb). If a 1000 pound bale of stover costs $30, it's $.03 per pound ($30 ÷ 1000 lb = .03/lb). However, the net energy for maintenance (NE_m) of stover is only 51% of that for corn (1.14 Mcal/kg versus 2.24 Mcal/kg). Therefore, on an energy basis for maintenance, they cost the same. However, the net energy for gain (NE_g) of corn is 2.7 times higher than that of corn stover (1.55 Mcal/kg versus .58 Mcal/kg) making corn a more economical energy feed for gain. If corn is $.06 per pound the price per pound of corn stover would have to be $.022 to be equivalent for gain ($.06 ÷ 2.7 = $.022), making the price of a 1000 pound bale of stover be $22 to be equal for energy. **All of this assumes that corn stover and corn grain have the same digestibility, and protein content, which they don't.** If corn grain is 95% digestible, and corn stover is 55% digestible, poor feed intake may become a problem with corn stover, due to the length of time that the stover remains in the rumen before it is digested or chewed to particle sizes small enough to pass out of the rumen, and the corn grain becomes even more economical.

When comparing alternative energy feeds such as dried distillers grains and solubles (DDGS), corn gluten feed (CGF), or pelleted soybean hulls (SBH) with corn, it's still important to put things into perspective by looking at a price per pound. Once again, if corn is $3.36 per bushel, it's $.06 per pound ($3.36 ÷ 56 lb = .06/lb). In order for DDGS, CGF, or SBH to be the same price per pound, they would need to be $120 per ton ($120 ÷ 2000 lb = $.06). At that point, you can compare the benefits of each of the feeds. Corn is higher in energy. However, dried distillers grains and solubles and CGF have much more protein than corn, and that may be an important factor to consider. From the standpoint of energy availability, digestibility, and protein content, DDGS, CGF, and SBH are all superior to corn stover or soybean stubble bales as alternatives to hay or grass. In fact, soybean stubble that contains stems, pods, and leaves is only about 6 to 7% protein, but only about a third of the protein is digestible.

In many parts of the world, straw is fed as a roughage source to ruminant animals. While long-stem straw has a very low digestibility, varying between 35% and 55%, 'the grinding of straw increases consumption leading to higher digestible energy intakes of the order of 30%. In terms of net-energy intake the increase is somewhat more than this because the net-energy value of straw is increased by grinding.'
(Source: http://www.fao.org/DOCREP/003/X6510E/X6510E02.htm).
This brings up an important thing to consider, because of work done by Dr. Steve Loerch, here at The Ohio State University. Dr. Loerch states that "One effective option producers rarely consider is hay chopping. Chopping hay allows the cows to eat 25-30% more energy. Costs of chopping hay (equipment, labor, etc.) should be compared to costs of

purchasing supplemental energy. For some producers, this may be a cost effective option. I came to realize the potential of hay chopping from an observation at the OARDC Beef Center in Wooster. Steers fed a chopped hay based diet gained 2.5 lbs/day while those fed round baled hay (same hay source) in a rack gained less than 1.5 lbs/day."

So, if you are using corn stover or baled soybean stubble as a cow feed, here is what you need to remember: Dry beef cows will need a diet that is 7-8% protein in the middle third of pregnancy and 8-9% protein in the last third of pregnancy. Pregnant yearling heifers will need a diet that is at least 11-12% protein, and heifers and cows nursing calves will need a diet that contains at least 12% protein. Keep in mind that if heifers and young cows are not separated from the older cows they will be pushed out of the way when supplements are fed, and they will probably not receive the supplementation needed. With low-quality feeds, it is best to feed combinations of ruminally available (urea, soybean meal) and ruminally escape (corn gluten meal, distillers dried grains, fishmeal) protein sources. Soybean meal is an excellent protein source with low-quality forages, because approximately 80% of the soybean meal is degraded in the rumen, and the rumen microbial population must be given a source of N so that they can reproduce, before they can digest the low-protein forages. Additionally, if you are using corn stover, straw, or baled soybean stubble as the main source of forage, it may be necessary to supplement a high-energy feed to your cattle such as corn, DDGS, CGF, or SBH in order to keep the animals in the proper body condition. If labor is an issue, and it is not feasible to feed protein supplements daily, it might be more appropriate to use protein tubs or protein/mineral kegs for supplementation with low-protein feeds such as straw, corn stover, or soybean stubble. However, you can expect to pay 2 to 4 times more for this convenience than if you had purchased a soybean meal and DDGS combination and fed it daily. Finally, please keep in mind that the mineral nutrition of your cow herd should not be compromised due to the need to purchase additional feed. Having a good mineral program will enhance performance, allow the animals to convert energy more efficiently, improve calf survivability and growth, and reduce the post-partum interval from calving to rebreeding.

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