FEEDING ETHANOL BYPRODUCTS TO CATTLE

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Dr. Erickson received his BS degree from Iowa State University in 1995 followed by MS and PhD degrees from the University of Nebraska-Lincoln under the direction of Drs. Terry Klopfenstein and Todd Milton. He has been on faculty in the Department of Animal Science at the University of Nebraska-Lincoln since 2001 working in the feedlot cattle nutrition area. Dr. Erickson was granted tenure and promotion in 2006 to associate professor. His appointment is 50% research, 40% extension, and 10% teaching. He serves as the Beef Feedlot Extension Specialist for the University of Nebraska as well as research areas such as corn milling byproduct utilization, nutrition and environmental interactions, growth promotion, production systems, and decreasing E .coli O157:H7 in feedlot cattle.

I was charged with talking about how we feed ethanol by-products. We've been feeding distillers grains for 150 years, mostly from whiskey distilleries.

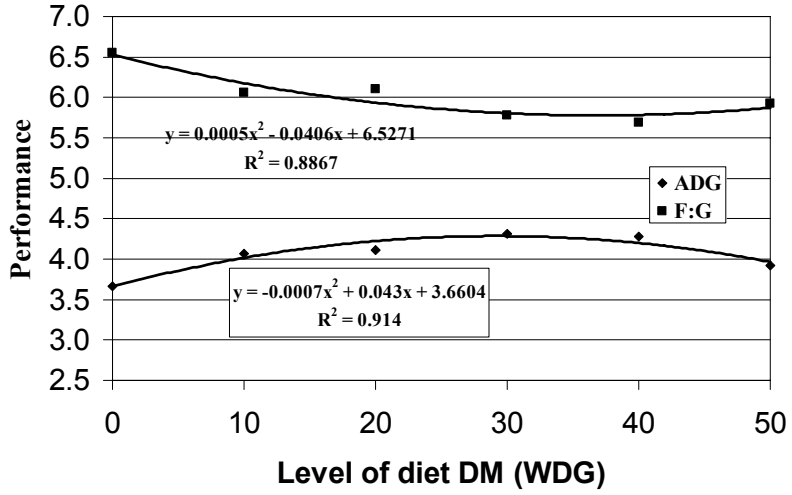
I'm going to focus on just beef cattle and talk about dry and wet. There are two schools of thought. You can use low levels (less than 15% of the diet or 2-3 lbs) as a protein source and it works well. There are really no issues. Based on everything you've been exposed to so far, I think our focus has to be on using greater levels (more than 15%or 4 lbs) to use up byproducts, especially if it is economical. Our focus at least at Nebraska has historically been that it works okay as a protein, but now how do we use more of it and focus on it as an energy source?

If you have cattle close to the plants, wet feed is a good option. That has been our perspective at Nebraska and certainly there is some wet feed marketed in all states. Dry byproducts can also be important so I'll try and cover both wet and dry byproduct feeding. My focus is feedlot cattle which can use large quantities of wet byproducts. Fat and sulfur will be two of the critical things, maybe phosphorous as well, in the future for feedlot cattle for using greater amounts of distillers grains. Dry distillers grains are a bit "cube-challenged" and we'll have to work at that in the future to get it distributed to ranchers who want to have hard cubes to supplement.

Distillers grains plus solubles

One study by Vander Pol et al. (2006) fed wet distillers grains plus solubles from 0-50% at 10% inclusion levels. These percentages are on a dry matter (DM) basis. Many producers will tell you they are feeding at 30%, but that is how much they weigh out in the truck, or the percentage on an "as-is" basis. With wet feed ingredients, there is tremendous difference between as-fed percentages and dry matter percentages. Nutritionally, DM is all that matters. In Figure 1, the bottom line is gain and the top line is feed conversion. We have consistently observed improved gain and feed conversion when we replace corn with wet distillers grains plus solubles.

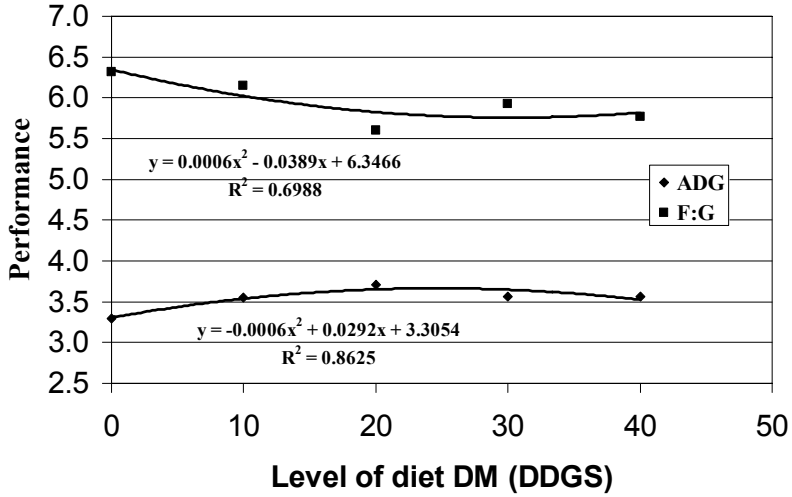
Efficiency value



Vander Pol et al., 2006 Nebraska Beef Rep. and 2005 Midwest ASAS

Dr. Mader, in northeast Nebraska, has evaluated dry distillers grains plus solubles with a similar approach (Buckner et al., 2007). The top line is feed conversion and the bottom line is average daily gain. We observed a nice response up to 20% of diet DM, but not quite the same response as the wet distillers grains. As you go higher than 20% inclusion of dry distillers grains, there can be some challenges in the bunk such as mixing and handling. That is one of the advantages of a wet ingredient -- it actually conditions the ration, improves the mix and holds the ingredients together.

Efficiency value



Buckner et al., 2007 Nebraska Beef Rep.

Bremer et al. (2006) summarized University of Nebraska research using wet distillers grains plus solubles in diets with dry rolled and high-moisture corn diets. This summary was for performance and carcass characteristics. This is the list of the individual studies and the amounts of WDGS that were fed. The last column is head per treatment. That is not total head, there were actually over 1200 head and 34 treatment comparisons.

UNL Studies Used

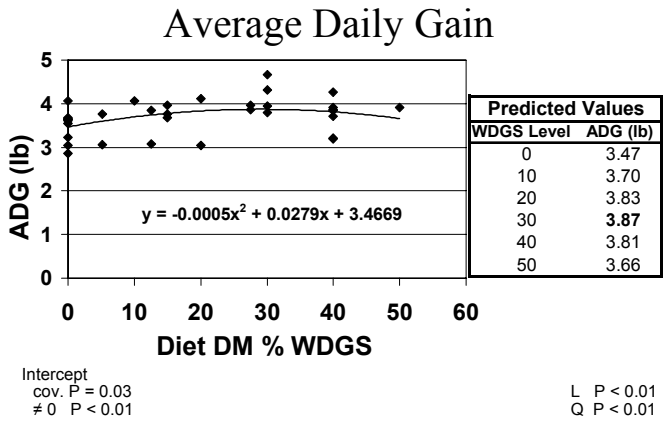
Experiment	Year	Diet DM % WDGS	Hd/Tx
Sindt et al.	1990	0, 5.2, 12.6, 40	40
Larson et al.	1991	0, 5.2, 12.6, 40	40
Ham et al.	1992	0, 40	32
Fanning et al.	1997	0, 30	20
Vander Pol et al.	2002	0, 20, 40	10
Vander Pol et al.	2004	0, 10, 20, 30, 40, 50	48
Buckner et al.	2005	0, 30	50
Corrigan et al.	2005	0, 15, 27.5, 40	40
Luebbe et al.	2005	0, 15, 30	32

Calves and yearlings are both in these data. In all studies, ADG was increased in a quadratic fashion up to 30 to 40% WDGS (DM basis) from 3.5 to 3.87 lb per day. A similar response was observed for feed conversion and fat depth. Feed conversion continues to improve up to 40% WDGS (DM basis). I would recommend producers use 30-40% replacement in feedlot diets with a couple of management considerations.

Cattle fed WDGS gained faster. With these experiments, especially for performance, do you compare them at an equal finish, or an equal days-on-feed? The easier way for researchers is to do equal days-on-feed. If I try to predict finish and maybe feed cattle longer that are on certain treatments causing lower gains to get them to the same finish, inevitably I'm going to be wrong. The only way to do that is serial slaughter experiments which can be quite expensive. The point is these experiments are all with equal days-on-feed.

It shouldn't be too surprising that if cattle gain more as you add wet distillers grains in place of corn, they tend to get fatter as well. We observed a quadratic response for marbling score as well with an increase up to 30% WDGS, which was part of why we summarized the data.

At least at intermediate levels of WDGS (10-40%) with equal days-on-feed and in diets with dry-rolled corn and high-moisture corn, cattle in our experiments have converted more efficiently, gained more, tended to get fatter quicker, and marbled better.



Feed Conversion

Predicted Values	
WDGS Level	F:G
0	6.44
10	6.16
20	5.95
30	5.81
40	5.74
50	**5.73**

12th Rib Fat Depth

Predicted Values	
WDGS Level	FAT
0	0.49
10	0.52
20	0.54
30	0.54
40	0.52
50	0.49

Marbling Score

Predicted Values	
WDGS Level	Marbling
0	518
10	528
20	533
30	532
40	526
50	514

Corn gluten feed

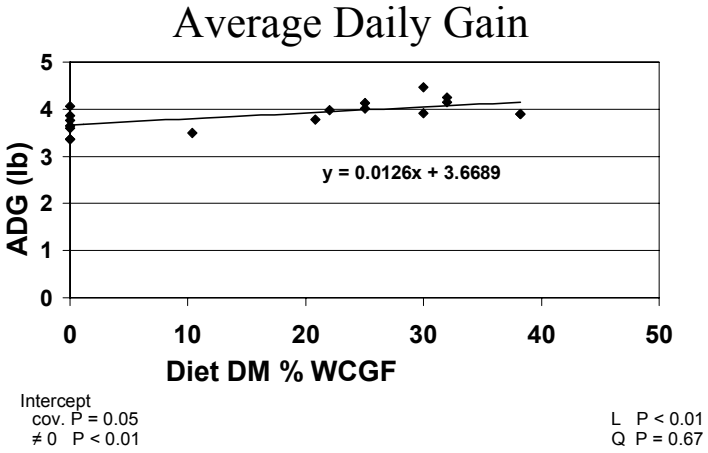
We conducted a similar approach with gluten feed. You may be familiar with Sweet Bran (Cargill, Blair, NE) that is shipped from Iowa to Texas. Therefore, wet corn gluten feed is being fed not only in Nebraska but in other major cattle feeding areas. The two plants that are wet mills in Nebraska produce all of their feed in the wet form and ship locally to feedlots. The expansion we're seeing is mostly distillers grains. However, more wet corn gluten feed will also be produced, therefore, it is certainly still an important byproduct feed for feedlots.

Corn gluten feed is considerably lower in protein than distillers grains because the corn gluten meal is the protein fraction that is removed during the wet milling process. Corn gluten feed is also lower in fat than distillers grains.

Corn Gluten Feeds:

- 19-24% CP(80% DIP), .9% P, 2.0% fat, 40% NDF
- High fiber energy source with high digestibility
- Energy content – 85 (dry) -110 % (wet) of corn
- Sulfur content - .40%

Bremer et al. (2007) summarized University of Nebraska experiments with wet corn gluten feed (Sweet Bran; Cargill Wet Milling). We evaluated 18 treatment means (over 800 steers) where wet corn gluten feed was replacing 0 to 40% of either dry-rolled or high-moisture corn. Average daily gain increased in a linear, not quadratic fashion. Feed conversion linearly decreased as you increase wet corn gluten feed up to 40%. The energy value is approximately 109% of corn. Marbling is increased in a linear fashion as corn gluten feed increases. In all of our controlled studies, performance has been enhanced and cattle performed quite well on a carcass basis.



Corn processing within diets containing byproducts

Corn can be processed as dry-rolled corn, high-moisture corn, steam-flaked corn or whole (unprocessed) corn. Feeding byproducts (with starch removed) changes rumen metabolism. The decrease in starch has marked changes on rumen pH and makes feeding cattle easier. A common observation from feedlot producers in Nebraska that began utilizing by-products is that keeping cattle on feed is easier because they are not feeding as much starch. If that's the case, maybe now you can more intensely process what corn is left in the diet with byproducts included. Whereas, in diets without byproducts, you would not feed high-moisture corn as the sole grain source due to difficulty of keeping cattle "on feed".

Macken et al. (2006) fed dry-rolled corn, fine-ground corn, rolled high-moisture corn, ground high-moisture corn and steam-flaked corn with all diets containing 25% wet corn gluten feed. Fine-ground corn was about 6% better, high-moisture corn was 10-13% better, and steam-flaked corn was about 18% better than feeding dry-rolled corn. Big response to more intense processing in diets with gluten feed. In diets without gluten feed, high-moisture corn is about 1% better than dry-rolled corn, probably not much different, whereas steam flaked corn is 11% better than dry-rolling (Owens et al., 1997). In three experiments we have with diets with wet corn gluten feed, high-moisture corn is now about 8% better, flakes are now almost 15%. When you replace part of the diet with wet corn gluten feed, we observe a greater response to more intense processing.

Therefore, we attempted to test a similar hypothesis with distillers grains. Vander Pol et al. (2006) fed whole corn, dry-rolled corn, 50-50% blend of dry-rolled and high-

moisture corn, high-moisture corn, steam flaked corn, and fine ground corn. Gains were good for whole corn, dry-rolled corn, and high-moisture corn. However, ADG was lower for cattle fed steam-flaked corn and fine-ground corn. Feeding whole corn relative to dry-rolled corn wasn't quite as good for feed conversion which was sort of expected. But high-moisture corn was about 6% better. But, cattle fed steam-flaked corn were surprising in that feed conversion was not improved, but poorer. This observation led us to one more experiment by Corrigan et al. in our 2007 Beef Report.

WDGS & Grain Processing

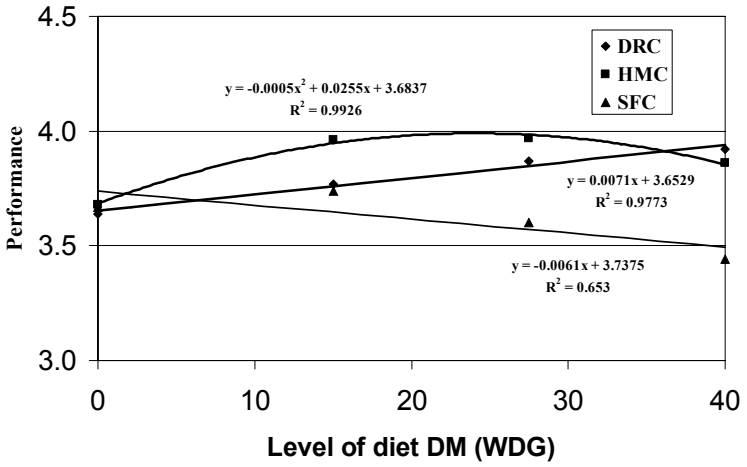
	WC	DRC	D/H	HMC	SFC	FGC
DMI	23.1^{a}	22.6^{a}	21.5^{b}	21.0^{bc}	20.4^{c}	20.4^{c}
ADG	3.85^{a}	4.05^{b}	3.91^{ab}	3.89^{ab}	3.59^{c}	3.38^{d}
F:G	6.07^{a}	5.68^{bc}	5.61^{bc}	5.46^{c}	5.76^{b}	6.15^{a}
Corn:	-11.2	--	2.0	6.3	-2.3	-13.5

All diets contained 30% WDGS; 61.4% corn
Calf-feds 168 days, initial weight = 700 lb

Vander Pol et al., 2006 Nebraska Beef Rep.

The following slide is a perfect description of an interaction. We fed zero, 15, 27.5 and 40% distillers grains. We did that in diets that were based on dry-rolled corn (middle line), diets which were based on high-moisture corn (top line) or diets that were based on steam-flaked corn (bottom line). This is average daily gain. These data suggest as you add wet distillers grains plus solubles in high-moisture-corn based diets, we observed a quadratic and nice improvement in gain. Cattle fed dry-rolled corn had a nice linear increase in average daily gain with added wet distillers grains. Cattle fed steam-flaked corn with added WDGS did not gain more, in fact gain was decreasing as WDGS was added. Our data suggests that there's an interaction with WDGS in flake-corn diets. That has some implications and we have to figure out why. I think that this is an important thing to keep in mind especially if you work with a lot of feedlots that would use flake corn that distillers grains are still good and work well up to 20%, but probably not the 30-40% like I would recommend with dry-rolled corn.

WDGS & Grain Processing



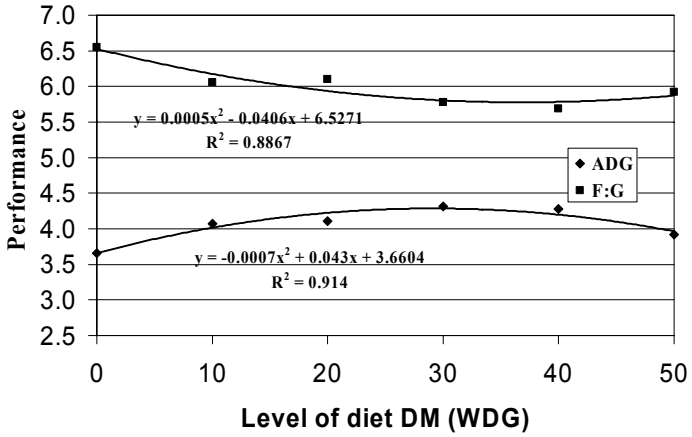
Corrigan et al., 2007 Nebraska Beef Rep.

Limitations

Our focus at Nebraska is how do we use more? It's been made very clear to me that for us to figure this out and to be making opportunities for Nebraska we should figure out ways to feed more if it's economical. I think there are two limitations for feeding really high levels of wet distillers grains, fat and sulfur. We might be able to solve the fat problem if we put wet corn gluten feed (low in fat) and wet distillers grains (high in fat) together.

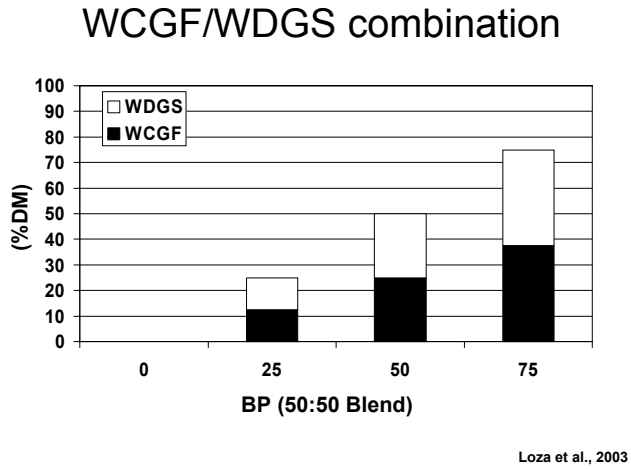
Vander Pol's work shows that ADG and feed conversion get poorer as WDGS inclusion increases above 40%, and we believe it's either fat or sulfur. So, 40% WDGS in diets is probably the maximum based on S and fat.

Efficiency value



Vander Pol et al., 2006 Nebraska Beef Rep. and 2005 Midwest ASAS

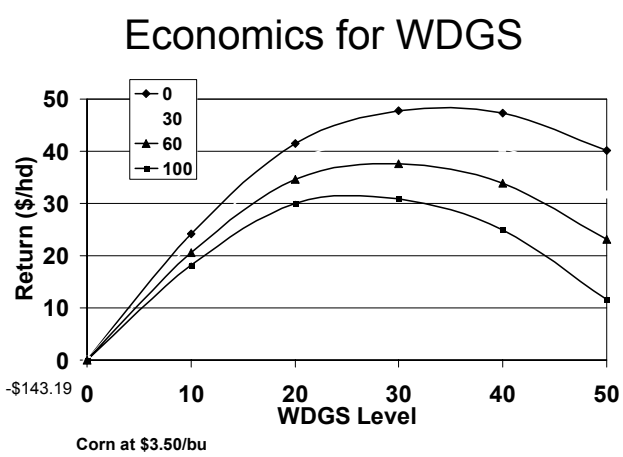
Another reason for thinking that way is looking at older work from Nebraska where we fed 0%, 17%, 35% all the way up to 87.5% gluten feed. There was no statistical difference in gains and feed conversions for cattle fed corn based diets or diets consisting of only wet corn gluten feed. Therefore, our concept was to feed 0%, 25%, 50% or 75% by-product with byproduct consisting of a 50:50 blend of wet distillers grains plus solubles and wet corn gluten feed. Gain responded in a quadratic fashion and we had tremendous gains at the 50% level, then it came back down. You might think that the 75% by-product didn't work, but notice that the gains were as good as the ones fed straight corn. Feed conversion was about the mirror image with fairly dramatic improvements up to 50% and 75% went back and was similar to cattle fed corn. But, feeding 75% byproduct as a blend of WDGS and wet corn gluten feed was as good as feeding corn, and may be more economical if byproducts are cheaper than corn.



Economics

There are a lot of different by-products and processes. Plants are different and we need to have some type of way to predict economic returns when feeding byproducts. Therefore, Buckner et al. (2007) developed an economic model where producers can plug in what they are feeding, what their cattle prices are, what they can get their by-products bought for and determine what their economic response is. That will be available on our website in the near future at http://beef.unl.edu.

In Nebraska it has been quite economical. These are data we evaluated where corn is priced at $3.50 per bushel, and cattle prices from September, 2006. If you use cattle prices from September and corn at $3.50, cattle just fed corn lost $140 on this break-even projection, but when you added wet distillers grains, the cattle producer could make between $20-50 more per head. I think that's really big for those areas that are near ethanol plants and can buy wet byproducts economically.



Forages

There are numerous reasons why feeding these by-products may be a really good fit in forage situations. These situations could be backgrounding, stocker operations or in cow-calf situations. There are numerous reasons why they may fit. We supplement a lot of protein historically, especially in the winter to cattle fed forage-based diets. These byproducts are excellent protein sources. The distillers is high in by-pass protein which may be beneficial at times. We've talked about energy. The fat will certainly be a good energy source even in forage-based diets.

How many times do we supplement forage with phosphorous whether they need it or not? We've gotten away from supplementing phosphorous in feedlot diets for good reason and it can be a negative in feedlot diets, but for cows this could be a real plus. You can eliminate that phosphorous supplement because distillers is high in phosphorous.

We have learned that when you replace forage with starch, there can be some negative interactions in the rumen. Byproducts do not have starch, so there are no negative associative effects.

You can bring in distillers grains and it will do all of these things, instead of buying a protein supplement and a phosphorous mineral, etc.

Reasons for feeding distillers grains with forage

- Crude Protein
- Undegradable Protein
- Energy
- P
- No Negative Assoc. Effects?
- "One Size Fits All"?

We've done a lot of supplementation of gluten feed. Work in the 1990s with calves grown on corn stalks or on ammoniated wheat straw through the winter and cattle that were just given a protein supplement of 1.8 lbs. gained about .5 lb. per day which is typical with what we see in our backgrounding system with just protein. We fed 4 lbs. of

corn, 1.8 lbs. of protein and cattle gained about 1.4 lb per day, which would be typical. We fed 5 lbs. of gluten feed and only .18 lbs. of supplement. We didn't need any protein because gluten feed provided protein in it and calves gained about the same 1.4 lb per day. I think you can replace corn and protein with gluten feed and supplementing calves in a backgrounding situation and expect the same performance.

A study where different levels of gluten feed were fed to calves grazing stalks, and there was a nice gain response at least feeding up to 6 lb (DM basis) of wet gluten feed per day. If you have producers who are backgrounding calves on stalks, I would supplement them with some by-product and expect better performance.

Same thing but now with dry distillers grains we had a nice gain response as you increase from 1.5 lb up to 6 lb of dry distillers grains.

In another study, a high-quality and low-quality forage were fed. Cattle that were not given dry distillers grains did not gain much on low-quality forage. They gained over 1 lb. per day on high-quality forage. But in both the low and high quality forage situations, gain was increased in a quadratic manner as you increased dried distillers grains, while forage intake decreased. We were intrigued by this and wondered will they replace forage and still get better gain? The hard part is the work we've done with cows suggest they don't read the protocol and they don't eat less forage when they get supplemented. When they are out in a grazing situation they don't displace enough forge to just maintain weight. They gain condition.

In another study calves were fed 0, 4 or 7.5 lbs. dry distillers grains, both in grazed cattle and in penned calves (Klopfenstein et al., 2007). Gain increased dramatically in both cases. I think these by-products work well in forage situations.

DDGS Summary

	DDGS, lb/d		
	0	4	7.5
Grazing yrl.	1.60	2.13	2.49
Penned calves[a]	1.62	2.34	2.97
Economics	--	$1.94	$1.41

[a]One lb DDGS replaced .5 lb forage.

Gluten feed and heifer development

I want to bring up some work that Don Adams and others at North Platte have done at a commercial ranch in the Sand Hills looking at heifer development systems. This is commercial data and there are good numbers of heifers and two treatments. The two treatments were imposed on developing heifers and compared a traditional hay-type system to a non-traditional by-product feeding situation. These heifers were grazing winter range and those are estimates of how much range they were consuming, and they were given a supplement. As most ranchers have done forever, that range was gradually replaced with hay as the heifers got close to calving.

In the treatment system, those heifers were forced to graze winter range all the way through, but gluten feed was supplemented with increasing amounts of dry gluten feed.

Feeding Schedule, lb/d

	Control			Treatment		
	Range	*Supp.*	Hay	Range	*Supp.*	Hay
Oct	19.4	0.7	.	19.4	0.7	.
Nov	19.1	0.9	.	19.1	0.9	.
Dec	13.2	0.9	5.1	17.8	4.0	.
Jan	7.7	0.9	11.9	16.3	3.5	.
Feb 1	1.8	1.1	17.2	14.1	5.1	.
Feb 15	1.1	1.5	18.9	13.0	6.8	.

This was a commercial ranch with over 1300 heifers in each case. Percent pregnancies were not different – 96%. But this treatment system of not using hay and using gluten feed saved the ranch about $6-7.80 per heifer.

In another study the same approach was used with over 1300 heifers. However, instead of gluten feed, heifers were fed dry distillers grains compared to supplement and hay. Pregnancy was the same, but there was about an $8 advantage on the dry distillers grains.

Storage problems

Storage of traditional wet distillers grains plus solubles (35% DM) is a problem. This stuff has the consistency of mashed potatoes. When you drive on it, it basically oozes out. We tried to figure out ways to make this store better for two reasons. One is for feedlots to buy a bunch in the summer and use it throughout the year. Secondly for ranchers to be able to buy a bunch in the summer and use whenever they needed to through the rest of the year. If you put this in a bag and put any pressure on it you will have to re-bag it the next day. You can put it in a bag with no pressure and it'll work okay but it takes greater storage area, and more bag. It really spreads out so that's why you can't put any pressure on it.

We wanted to figure out a way to add things to this to be able to bag it under normal pressure or store it in a bunker. We tried a bunch of different things. We tried dry distillers grains mixed with it, wheat straw, grass hay, things to bulk it up to put pressure on it. We put some in a bunker, mixed in grass hay and packed it in.

Our recommendations are if you are going to bag it, you mix in on a dry basis 15% grass hay and it'll bag at normal pressure, 300 psi. It took more alfalfa hay and I probably wouldn't recommend that.

	Bagging[a]	Bunker
Grass hay	15%	30-40
Wheat straw	12.5	25-32
Alfalfa hay	22.5	45-55?
DDGS	50	---
ADMCGF	60	---

[a]300 PSI.

In a bunker it takes more forage but we only tried grass hay so we're guessing at the rest of them. I know a lot who are going to try corn stalks this year.

We don't have the answers on the storage thing, but we want to have a starting point for producers to work on storing large quantities. It will take ingenuity to figure out how to use these in the wet form if you are close to the plants.

Conclusions

By-products are here, we need to use them and they can be economical. They increase average daily gain and improve feed conversion in feedlot situation. I don't want you to forget about gluten feed because we are going to have to feed that up as well but I think it's true that we'll have more distillers grains than gluten feed in the future.

Dry by-products are different and they work well on a lot of applications but the maximum level you should feed is probably lower. All distillers grains are not created equal. Energy content is consistently better than corn which was a surprise to many people. These products work well in forage-based diets but they are sort of limited on how much they can use. I think there are some applications.

In distillers grains, phosphorous is elevated and there's plenty of protein. There are storage, handling and feeding challenges, not just on wet product but on dry. We have to figure out a way to get this into cube and pellet form if our producers are going to use a lot, or figure out some other method to use it in a dry, meal or in the wet form.

I've said a lot of positive things about by-products based on our research data. But, the whole premise here is that byproducts will be economical. Byproducts have been economical in the past and we presume they will be very economical in the future.Most of our research and extension material on byproducts is available on our beef website at http://beef.unl.edu, there is a by-products tab you can click on and find out about the storage and a general handout on feeding byproducts to beef cattle. All of our beef reports are also available at this website under the reports tab.

QUESTIONS

Question: When you've done the trials have you done any work where you've actually evaluated the meat for fatty acid content?

Erickson: We're right in the middle of that. We're working with Chris Calkins and there has been three experiments where we've carried this on through from our feeding study.

In all of our studies, we go into the packing plant and collect traditional carcass data, weights, marbling and fat depth, but the key there is that Dr. Calkins takes it to the next step and when it's going through processing and they are cutting it up, he buys back some of the meat. He does some taste tests and some tenderness testing. He's got some funding from the Nebraska Beef Council and there are some calls out there to really make sure this quality thing is not influenced when you go to high levels. That's not cheap work. It takes large amounts of research dollars to get the cattle set up on these research trials and then to buy back that beef for further evaluations.

Question: On the storage issue, last summer we took big squares and piled it in there with nothing added, let it form the crust and we seemed to get along all right. What about the mold a previous speaker mentioned? What does that cost and do you gain enough to pay for it? We think we got along good just storing it without adding anything. We tested it going in and going out. It sat there two months in the heat of the summer and we got along good. Inside those bales we put black plastic like you put over corn silage. It was on a concrete slab and we lined square bales on the inside with black plastic. It was very inexpensive and we got along good.

Erickson: I've heard a lot of anecdotal stories like that from producers who have tried it. I heard it works really well with gluten feed. I've not heard a lot of stories on the wet distillers grains but it doesn't surprise me that if it forms a crust, then it might work okay. I think that is a key. I have been a little nervous that if it forms a crust and cracks, then you run the risk of potentially spoiling the whole pile. The data and pictures I have presented are more of a conservative way to store it. I think it will work okay, but to answer your question on preservatives, there are preservatives out there and you can treat it with acids and other things.

The problem is that this stuff is fairly acidic already. It comes out at a very low pH. That is part of the reason it tends to keep especially if you get a crust formed. My impression of a lot of preservatives is that they can be cost-prohibitive. If there was a free or cheap preservative out there, I'd been supportive of trying it. We should be doing more on these storage issues.

In Illinois they are looking at spraying on an edible cover that you seal up instead of having to take plastic off, you just feed it up. There are a lot of possibilities. It's going to be all of our jobs to try to figure out ways to make this work. I like the wet product from my perspective in Nebraska. We are going to be doing research on how we can feed the byproducts, how can it be stored, and work on delivery in the next few years at Nebraska. Somewhere we should have a clearinghouse of storage methods that have worked. I'm most interested in storage that doesn't work so that producers can avoid those methods, but no one ever tells me those.

Comment: We've seen some problems where the feed didn't look that bad but we were still having polio issues. The feed in conjunction with the water and a high sulfur content in the water caused a problem.

Erickson: That is a good point. I would recommend looking at feed and water. You really need to combine the water and feed to determine what is going on and what is the

total maximum of sulfur. I do agree that bunk management is important, but some of those levels I showed you, we induced polio on our research situations. I have first hand experience with it and I am worried because I'm telling you to go to 40% and I know if you do that in some parts of the country in some times of high stress in those cattle, you'll induce some brainers. I think one good option is for us to figure out some way to not use as much sulfur in the process. That will be a fairly long road to go down. I will challenge the plants because they can do better.

If you are going to go to high levels of by-products, I would make sure you test your water beforehand. We've got pockets in a lot of different places where there are high sulfates in the water and there is no doubt that is as important or may be even more important than sulfur in feed. I would like for someone to research this besides me to figure out other ways to solve that. We commonly feed thiamine, we commonly IV with thiamine. I'm not sure it's 100% effective, but does appear to help solve some of the challenges. Sometimes we get a response sometimes we don't. It's difficult to test. It's kind of like disease and liver abscesses. If there is a small percentage of the population that is affected, you need to research this on large numbers of cattle.

I would for sure test the water and account for that percentage. NRC recommends 0.4% sulfur in the diet as a maximum. I'm sure that's not a hard and fast rule because the only time we've seen the most polio challenge in what we think are sulfur-induced brainers is shortly after step up periods or during other times of stress. Clearly it's also interacting with rumen pH. There are a lot of studies out there but you have to piece them all together to get a complete picture.