Feeding/Nutrition

Bud Patterson, Patterson Nutrition Co.
970/580-1435 · pattersonnutrition@yahoo.com

Bud received his BS and MS from West Texas State University in Ruminant Nutrition. He spent 28 years as the District Nutritionist with Farr Feeds and Cargill Animal Nutrition. In 2001 Bud started Patterson Nutrition Co., a private consulting firm, working with Range and Feedlot animals in the Western U.S. He has worked with bison producers since 1999.

-- FEEDING CO-PRODUCTS IN BISON RATIONS

Co-products in Beef Cattle Rations

H. H. "Bud" Patterson, Patterson Nutrition Co.; Sterling, Colorado
H. H. "Trey" Patterson, Padlock Ranch; Ranchester, Wyoming

The practice of feeding co-products in beef cattle rations dates back to the early days of beef finishing. In California in the 1940's, feeders utilized co-products from vegetable processing in feedlot rations. These included artichoke hearts, citrus pulp, grape and apple pomace, and cull carrots. Early Texas feeders used cottonseed meal and hulls from near-by cotton oil plants. Mid-western feedlots used soybean meal and hulls from soy processing plants and wheat midds from flour mills, while Northwestern feedlots utilized wet potato waste from near-by processing plants. Although many feeders continue to use some of these same co-products, several new products have entered the feeding industry in the past 10 years that have changed the way nutritionists formulate rations and dispelled some old paradigms in ration formulation.

Co-product feeds can be valuable to both feedlot and range nutrition programs for beef cattle. Modern feeders utilize co-products in feedlot rations to decrease ration costs, provide protein, increase energy level and efficiency, reduce roughage levels, and reduce digestive problems. In range programs, co-products can provide high-quality protein and energy to support production goals. Co-products are not always a magic bullet, however. There are limitations and considerations to their use. We will discuss a few of the major co-products used today and explain the applied use of these products in beef cattle rations.

(Editors Note: the complete document can be emailed to you by your request to the RMBA office email: buffaloranchers@yahoo.com)

- **IMPORTANCE OF MINERAL NUTRITION IN RANGE BISON**

Co-products in Beef Cattle Rations

H. H. "Bud" Patterson, Patterson Nutrition Co.; Sterling, Colorado
H. H. "Trey" Patterson, Padlock Ranch; Ranchester, Wyoming

Introduction

The practice of feeding co-products in beef cattle rations dates back to the early days of beef finishing. In California in the 1940's, feeders utilized co-products from vegetable processing in feedlot rations. These included artichoke hearts, citrus pulp, grape and apple pomace, and cull carrots. Early Texas feeders used cottonseed meal and hulls from near-by cotton oil plants. Mid-western feedlots used soybean meal and hulls from soy processing plants and wheat midds from flour mills, while Northwestern feedlots utilized wet potato waste from near-by processing plants. Although many feeders continue to use some of these same co-products, several new products have entered the feeding industry in the past 10 years that have changed the way nutritionists formulate rations and dispelled some old paradigms in ration formulation.

Co-product feeds can be valuable to both feedlot and range nutrition programs for beef cattle. Modern feeders utilize co-products in feedlot rations to decrease ration costs, provide protein, increase energy level and efficiency, reduce roughage levels, and reduce digestive problems. In range programs, co-products can provide high-quality protein and energy to support production goals. Co-products are not always a magic bullet, however. There are limitations and considerations to their use. We will discuss a few of the major co-products used today and explain the applied use of these products in beef cattle rations.

Corn Co-products

Many co-products found today in the Mid-Western and Western states are derived from the wet corn milling and ethanol production industries which have grown tremendously in recent years. It has been estimated that 20% of the nations' corn crop will be utilized by these processing plants in the near future, providing a large amount of co-products for the feeding industry. It is important to understand the difference in corn gluten feed and corn gluten meal, co-products of wet corn milling, and distillers grains, a co-product of dry corn milling. Table 1 shows the nutrient value of some corn-co products.

*Corn gluten feed***.** Corn gluten feed (CGF) is derived from the wet corn milling process of producing high-fructose corn syrup. Corn is steeped and the bran, germ, gluten, and starch are separated out. The starch is then subjected to enzymes to produce high fructose corn syrup or fermented with yeast to produce ethanol. The separated products can be sold as separate constituents, which is usually the fate of the gluten (corn gluten meal) and germ (corn-oil). Corn steep can be added back to bran to produce wet CGF (40-60 DM), and that can be subsequently dried to produce dried CGF (88-90% DM). Some plants will add some corn germ back to the gluten feed product, increasing the energy content.

Crude protein content of CGF is about 21% (DM basis), which is 75-80 % degradable in the rumen (DIP; Table 1). Phosphorus and sulfur typically run 1.0 and 0.4% of DM, respectively. Note from Table 1 that sulfur can be as high 0.9% in some instances. The energy value ranges from 90 to 120% then energy value of corn. Corn gluten meal is high in protein and undegradable intake protein (UIP; Table 1); this product is usually used by the dairy industry.

Distillers Grains. Distillers grains are a co-product of dry-corn milling, which is the process of producing ethanol. In brief, corn is processed and subjected to fermentation with yeast. The ethanol is then distilled off and the remaining whole stillage is centrifuged to produce wet distillers grains (course solids) and thin stillage. The thin stillage is further evaporated to produce condensed distillers solubles (syrup; 23-45% DM). The condensed solubles can be marketed separately or added back to the distillers grains to form wet distillers grains plus solubles (23-35% DM). Distillers grains can be further dried to produce dried distillers grains (plus solubles if applicable; DDG or DDGS; 88-90% DM).

The crude protein content of distillers is 25-35% of DM, which is about 50% DIP (Table 1). This means that one-half of the protein in distillers grains is UIP. Energy values range from 100 to 150% that of corn. Like CGF, distillers grains contain high phosphorus and sulfur. Since the germ is not removed in dry milling, distillers grains contain 8-12% fat.

Corn co-products in feedlot rations. Corn co-products, in general, provide both protein and energy to feedlot rations. At first intuition, one would think that the removal of the starch from these products would markedly reduce energy levels. Note that what is left after starch removal is highly digestible fiber, organic acids, protein, and minerals. The result is an energy dense feed, and in the case of distillers, also has elevated fat. But how can the products have a higher energy value than corn? Replacing corn with these co-products in finishing rations can result in improved performance due the reduction in negative effects associated with low rumen pH and subacute acidosis. In addition, the replacement of corn with these products in growing diets reduces negative associative effects associated with feeding starch with forages (Rick Stock, personal communication, 1999).

Nebraska research indicates an ADG increase of 10% (P<.01) and improvement in F/G of 8% (P<.01) when wet distillers grain replaced dry corn at 30% of the dry matter diet of yearling steers (Al-Suwaiegh et al., 2002). As a bonus, the UIP content of distillers grains provides highly digestible protein for degradation in the lower GI tract, enhancing performance in many fast growing young animals (Klopfenstein and Goedeken, 1986; Creighten et al., 2001). With recommended feeding levels of corn co-products, adequate protein levels are usually achieved without the need for expensive supplemental protein.

Rations with dry grain co-products replacing dry corn will improve performance but not as much as wet grains (Trenkle, 1996; Klopfenstein, 1998;). Dry grain products like DDGS may have less oil content, apparently from volatilization of the fatty acids during the drying process, and consequently lower energy values compared to wet grain products. The wet grains also condition rations better, which can lead to improved bunk management and increased dry matter intakes.

Feeding wet grain co-products will involve wetter overall rations and thus higher consumption rates, so the feeder will have to mix and deliver more total feed per day to a given number of cattle. The trade-off here is most of the time we can eliminate or reduce corn silage, and reduce total roughage levels (due to lower starch levels in the rumen), which saves time in mixing. Wet grain co-products, unlike silage, do not have high acid contents from anaerobic fermentation that can inhibit intake of newly arrived feeder cattle. Commonly fed starter rations for yearlings will include about the same amount of wet distillers or brewers grains as we formulate in the finisher diets (Tables 2 and 2A).

Wet distillers grain also lends itself well to backgrounding rations. Usually fed at lower inclusion levels than finisher diets, wet distillers grain conditions high roughage rations and can again replace part of the corn silage. Tables 3 and 3A give an example of this type of ration. These rations are formulated for light (~450 lb.) calves backgrounded in late fall & winter in Southwestern Nebraska. Cattle receipts this time of year will be high-risk calves shipped-in from as far away as Missouri.

Wet grain co-products are easily stored outside or in an open front storage shed and have a shelf-life of 4-10 days, depending on the ambient temperature. Most feedyards schedule delivery of wet products so that each load can be fed in 2-5 days thus keeping the inventory fresh. The wet products can also be successfully stored in anaerobic storage bags. Without good anaerobic storage, significant spoilage losses can be expected if the product is not fed quickly.

Dried distillers grains usually comes in loose meal form. Due to the fat content, rancidity is a concern if the product is stored for long periods of time in hot and poorly ventilated conditions. We have successfully stored dried distillers for up to a year in three-sided commodity sheds. The product will set-up if exposed to moisture or cold; bridging may be a concern in overhead bins if you are not using the product rapidly. Dried CGF is marketed in a loose meal or a pellet. Bridging is also a concern in overheads. Shelf-life of the dried corn gluten feed in flat storage is good.

While providing a valuable feed ingredient, corn co-products do have limitations, including high phosphorus and sulfur levels, and high fat levels, particularly in wet distillers grains (~12% DMB). The high phosphorus comes from concentration after fermentation or extraction of starches from the grain. High sulfur levels come from concentration and from the processing procedures which add sulfur. With environmental considerations for phosphorus, and nutritional considerations for high sulfur levels, nutritionists need to be cautious in formulation and closely monitor mineral levels in other ration ingredients as well as sulfate levels in the water. NRC (1996) lists minimum sulfur requirement at 0.15 % and a maximum tolerable level of 0.40 % of the diet dry matter for cattle. High sulfate levels in the water (>1700 mg/L) have also been associated with Polioencephalomalacia (PEM), and poor calf performance (Patterson et al., 2002; Patterson et al., 2003). The combination of concerns of excess nitrogen, sulfur, phosphorus, and fat (in the case of distillers grains) will lead to maximum recommended levels being around 40-50% of dry matter. In cases where water sulfates are high, considerably less corn co-products may be used in feedlot operations.

Corn co-products for range cattle. By-products of corn milling also have application to range cattle nutrition. The protein, energy, and phosphorus are all valuable to foraging cattle. Since the starch is removed from these products, you do not have the negative associate effects observed when cereal grains are fed at high levels. In fact, research at Nebraska showed that distillers grains have a higher energy value than corn when supplemented to a high forage diet (Loy et al., 2003). Since corn co-products are usually priced relative to corn, they work well as energy supplements for foraging cattle. When cereal grains are used as an energy supplement to low quality forage, protein must also be supplemented to avoid a DIP deficiency and thus poor performance (Sanson et al., 1990). This is not the case with corn-co products that offer a combination of both protein and energy.

Loy et al. (2004) evaluated two systems of wintering pregnant heifers in two consecutive years (approximately 600 heifers/year). In the control system, heifers were fed a supplement designed to meet metabolizable protein (MP) requirements from October to February (calving began in March). The heifers grazed native range and were fed increasing levels of grass hay from December to February (range of 7 to 18 lbs). A treatment group was fed range pellets that were 72% dried corn gluten feed. The corn gluten feed was fed initially to meet MP requirements and then as an energy supplement to supply similar energy to that supplied by the combination of supplement and hay to the control group (CGF supplement fed at 0.7 to 7.5 lbs). Heifers fed the CGF supplement loss less condition than hay fed heifers in both years of the study and there were no differences in subsequent pregnancy rates (2-yr-old pregnancy approximately 96%). The corn gluten feed treatment cost $7/hd less than the hay treatment. Stalker et al. (2006) conducted a similar study with approximately 1300 bred heifers, except a DDGS based range pellet (60% DDGS) was used as the treatment group. Again, the DDGS-supplemented cattle had less body condition score loss during the winter than the hay-fed heifers. There were no differences in subsequent pregnancy rates and the heifers that were not fed hay had $10.47/hd less feed costs during the winter.

Working in South Dakota, Salverson et al. (2005) evaluated developing August-weaned heifers on native range and DDGS versus November-weaned heifers in a drylot (conventional system). August-weaned heifers were turned out onto ample winter range in September and remained on pasture all winter. November weaned heifers remained in the drylot after weaning and were fed grass hay and a wheat middling-based range pellet. Both groups of heifers were managed to achieve 65% of mature weight at breeding in June (about 860 lbs). To achieve the desired average daily gain for the heifers on range, DDGS was fed daily in feed bunks at a rate of 2-7 lbs per head each day. The rate of feeding was initially at 2 lbs and then gradually increased to 7 lbs by February. The rate then declined back down in the spring (we based this on estimates of forage quality and intake). Hay was only fed on two days during the winter to the range group when snow cover prevented grazing. All heifers were turned out to summer pasture on May 18. By design, heifers on the Range system were lighter at trial initiation because they were younger (early-weaned; Table 4). Also by design, they gained more during the experiment than the drylot heifers. However, they gained 1.68 lbs per day, rather than the target 1.5. This increase in gain was a result of the heifers performing better in the spring than expected. November-weaned/drylot heifers gained at the target rate of gain. There were no differences in the percentage of heifers cycling prior to breeding, synchronized conception, or overall pregnancy rages (Table 4). Accounting for the value of grazed forage, the daily cost of the drylot group was $0.74 compared to $0.52 for the range developed group.

A similar study was conducted at SDSU's Antelope Station in 2004 and 2005. In this study, approximately 117 crossbred heifers were weaned at similar times (Aug-Sept). On December 2, one-half of the heifers were turned out on native range and fed 5 lbs of a distillers grains-based range cube (fed daily; 60% DDGS). The other half remained in the drylot and were fed grass hay and a wheat middling-based supplement. Although both heifer systems in this study were designed to achieve similar gains during the winter, the range developed heifers gained 1.5 lbs/day compared to 1.3 for the drylot developed group. There was no difference in pregnancy rate between the two treatments.

Engel et al. (2005) evaluated DDGS versus soybean hulls (SBH) in limit-fed diets for bred heifers. Heifers were fed 9.0 lbs/d of grass hay and 7.25 or 6.60 lb/d of soybean hulls or DDGS (DM basis), respectively, during the last trimester of gestation. The objectives were to look at the impact on reproduction and performance since supplemental fat (Bellows, 1997) and UIP (Patterson et al., 2003b) have been shown to improve reproduction in young cows. DDGS has both UIP and fat. Heifers fed DDGS gained more weight during the winter (Table 5) than those fed SBH and tended to have higher subsequent pregnancy rates (92 and 80% for DDGS and SBH treatments, respectively).

What are the limits to feeding corn-co products to range cattle? Research has shown that up to 8 lbs fed to cows and calves has resulted in acceptable performance. Sulfur is likely a limiting factor. The only way to know those levels are to test all feedstuffs involved for sulfur and the water for sulfates. Table 6 shows the dietary sulfur levels if dry or lactating cows are supplemented with 0, 4, or 8 lbs (DM) of a co-product containing 0.4% dietary sulfur across two water sulfate levels (assuming base diet is 0.15% sulfur). Note that 8 lbs of DDGS does not result in excessive sulfur levels during the winter for dry cows, but if cows are lactating in moderate temperatures (such as spring) and consuming water with 1500 ppm of sulfates, their dietary sulfur levels would be at toxic levels (> 0.4%) with 8 lbs of co-product supplemented. Note that these co-products can contain more than 0.4% dietary sulfur, and some forages can contain high sulfur levels (Gould et al., 2002). Based on these calculations and considerations for dietary fat levels, the maximum level of DDGS and CGF that should be considered is around 10 lbs hd/d, depending on the type of feed and water that the cattle are consuming. Future research should challenge these limitations.

Feeding management can also become an issue. We have fed DDGS in a range cube and as a loose meal. Some have fed loose DDGS on the ground with successful results, but we recommend using feeding bunks or troughs if the loose meal is fed. Pelleting and cubing CGF and DDGS can be challenging and adds costs. One has to consider the management issues associated with storing and feeding these products when calculating their benefit.

Other Co-Products

Wet Brewers Grains. Wet Brewers Grain is composed of mainly Barley with a small amount of Rice. Neutral Detergent Fiber levels will be higher (55%) than Distillers Grain (40%) and the energy level lower. Brewers Grains, like other grain co-products have medium protein levels, and low starch, lending itself well to enhancing performance in backgrounding as well as finishing rations. Table 7 shows an example of how Wet Brewers Grains fits into these rations for growing and finishing cattle.

Wheat Midds. Wheat Midds are another commonly used co-product with highly digestible fiber and medium protein levels (approximately 17%). Midds are usually sold pelleted to feedyards and have limited use in finishing rations due to cost. The main use of pelleted wheat midds in feedyards in Colorado and surrounding states is in weaning and starter rations due to palatability and protein level as well as energy (~87% of dry corn), most of which comes from digestible fiber. Midds are also used as a protein supplement and weaning feed for ranches, and as a feed ingredient for feed mills. Table 8 indicates how Midds can be beneficial in calf weaning and starter rations in feedyards. Phosphorus levels in rations containing more than 25% midds can be extremely high depending on other ration ingredients, therefore care must be taken to keep calcium levels 1.5 -2 times higher than phosphorus.

Wheat midds have been shown to be an effective energy and protein supplement for cows (Dhuyvetter et al., 1999). The protein is predominately degraded in the rumen and is thus a good source of DIP. Wheat midds contain 25-35% starch, so high levels of (> 10 lb) may cause negative associative effects with low quality forage. However, work in North Dakota has shown that lactating cows consuming 16.7 lbs of midds along with straw and alfalfa performed similarly to cows fed corn silage and alfalfa rations (Dhuyvetter et al., 1999). Sulfur is not usually high in wheat midds, however phosphorus is usually around 1.0%. This can be beneficial for range cattle.

Wheat midds are hygroscopic, and thus will mold and set-up if stored without aeration in hot temperatures. Bridging in overhead bins can occur within weeks during the summer (Dhuyvetter et al., 1999). The loose meal is hard to handle and feed and will blow. Pelleted midds usually hold together well. If fines are low, wheat midd pellets can be fed on the ground.

Conclusions

Certainly there are more co-products than we have discussed in this paper, but the same principles of use apply. Many co-products offer high quality feed at commodity prices. The fiber-based co-products work well in backgrounding, finishing, and range conditions. They least-cost into many rations and feeding regimens due to the protein, energy and minerals that they contain. You have to be aware of the minerals, however.

Environmental concerns limit the amount of phosphorus and nitrogen that may be overfed in feedlots. Sulfur in corn-co products can create toxic situations and impair animal performance. These products are also variable. Never use book values, as you must analyze the feedstuffs and formulate appropriately. There can be variations between plants and loads from a given plan. Issues with handling, storing, and delivering co-products must be addressed and valued when making decisions on their use. High freight prices will limit the distance that wet products can be hauled. It is important to look at costs on a dry matter basis.

In summary, many feed co-products have been and continue to be used in beef cattle rations to enhance performance and lower production costs. Many of these products are of limited practical use elsewhere and would be a burden to grain and food processors if the cattle industry were not adept in their use. Thanks to the fine research done in many universities, our industry has learned to how use these products to the benefit of the producer, feeder, and ultimately the beef consumer.

Literature Cited

Al-Suwaiegh, S., K.C. Fanning, R.J. Grant, C.T. Milton, and T.J. Klopfenstein. 2002. Utilization of distillers grains from fermentation of sorghum and corn in diets for finishing beef and lactating dairy cattle. J. Anim. Sci. 80:1105-1111.

Bellows, R. A. 1997. Factors affecting calf survival. In: Proc. The Range Beef Cow Symposium XV, Rapid City, SD. Pp 141-150.

Creighton, K., M. Ullerich, and T. Klopfenstein, 2001. Undegradable intake protein supplementation of compensating, grazing Steers. University of Nebraska Beef Cattle Report. Page 34.

Dhuyvetter, J., K. Hoppe, and V. Anderson. 1999. Wheat middllings: A useful feed for cattle. North Dakota State University Extension AS-1175.

Engel, C., H. H. Patterson, G. A. Perry, and R. Haigh. 2005. Evaluation of dried distillers grains with solubles as a feedstuff for heifers in the last trimester of gestation. South Dakota State University Beef Report: Beef 2005-15:73-76.

Gould, D. H., D. A. Dargatz, F. B. Garry, D. W. Hamar, and P. F. Ross. 2002. Potentially hazardous sulfur conditions on beef cattle ranches in the United States. J. Am. Vet. Med. Assoc. 221:673-677.

Klopfenstein, T. 1998. Feeding distillers grains to ruminants. Proc. Distillers Grain Technology Council Symposium. April 1-2, Louisville, Ky.

Klopfenstein, T. and F. Goedeken. 1986. Bypass potential. Feed Management. Vol 37, No.12:12.

Loy, T. W., D. C. Adams, T. J. Klopfenstein, D. M. Feuz, J. A. Musgrave, and B. Teichert. 2004. A system for wintering spring-calving bred heifers without feeding hay. University of Nebraska Beef Cattle Report. Pp 7-9.

Loy T., T. Klopfenstein, G. Erickson, C. Macken. 2003. Value of dry distillers grains in high-forage diets and effect of supplementation frequency. University of Nebraska Beef Cattle Report. Pp 8-10.

NRC. 1996. Nutrient Requirements of Beef Cattle, 7th National Academy Press, Washington, DC.

Patterson, H. H., P. S. Johnson, and W.B. Epperson. 2003. Effect of total dissolved solids and sulfates in drinking water for growing steers. Proc. West. Sec. Amer. Soc. Anim. Sci: 54:378-380.

Patterson, H. H., P.S. Johnson, T.R. Patterson, D.B. Young and R. Haigh. 2002. Effects of water quality on performance and health of growing steers. Proc. West. Sec. Amer. Soc. Anim. Sci. 53:217-220.

Patterson, H. H., D. C. Adams, T. J. Klopfenstein, R. T. Clark, and B. Teichert. 2003b. Supplementation to meet metabolizable protein requirements of primiparous beef heifers: II. Pregnancy and economics. J. Anim. Sci. 81:563-570.

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. 68:595-603.

Salverson, R. R., H. H. Patterson, G. A. Perry, D. Young, and M. L. Gibson. 2005. Evaluation of performance and costs of two heifer development systems. South Dakota State University Beef Report. Beef 2005-04:13.

Stalker, L. A., D. C. Adams, and T. J. Klopfenstein. 2006. A system for wintering beef heifers using dried distillers grains. University of Nebraska Beef Report. Pp 13-15.

Trenkle. 1996. Ingredients for cattle feed: Byproducts from corn processing. Feed Management. Vol 47, No.11 Page 33.

Table 1. Composition of corn-co products (DM basis)[a].

Nutrient	Distillers Grains plus Solubles[b]	Condensed Distillers Solubles[c]	Corn Gluten Feed[d]	Corn Gluten Meal[e]
NEm, mcal/cwt	102-153	75-120	92-122	100
NEg, mcal/cwt	70-105	100-115	63-84	69
CP, %	25-35	20-30	15-21	66
UIP, % of CP	47-57	20	20-25	50-60
Fat, %	8-12	9-15	3-4	2-3
Calcium, %	0.02-0.20	0.03-0.17	0.10-0.15	0.08
Phosphorus, %	0.40-0.80	1.3-1.45	0.70-0.95	0.51
Potassium, %	0.5-1.33	1.75-2.25	1.0-1.5	0.21
Sulfur, %	0.37-0.7	0.37-0.95	0.40-0.90	0.72

[a]Adapted from:
Stock et al., 1995. Average Composition of Feeds Used in Nebraska. Univ. of Nebraska. G1048;
Tjardes and Wright, 2002. FeedingCorn Distiller's Co-Products to Beef Cattle. SDSU ExEx 2036.
NRC. 2001. Nutrient Requirements of Dairy Cattle.
[b]Wet grains are 25-35% DM; Dry grains are 88-90% DM.
[c]23-45% DM
[d]Wet feed is 40-60% DM; Dry feed is 88-90% DM.
[e]90-92 % DM.

Table 2. Step-up and finishing rations for yearlings containing distillers grains.

	Ration				
Ingredient, % AF	1	2	3	4	5
Alfalfa Hay	44.00	33.49	23.67	14.63	6.35
Cracked Corn	34.20	39.51	44.08	47.97	51.15
Wet Distillers Gr.	20.00	25.00	30.00	35.00	40.00
Finisher Suppl.	1.80	2.00	2.25	2.40	2.50
Nutrient					
DM, % AF	75.47	72.70	69.96	67.23	64.52
CP, % DM	15.21	14.80	14.44	14.13	13.89
NEm, Mcal/cwt	76.98	82.79	88.60	94.43	100.28
NEg, Mcal/cwt	48.50	53.50	58.50	63.50	68.50
Calcium, % DM	0.98	0.88	0.79	0.68	0.58
Phos., % DM	0.30	0.32	0.34	0.36	0.38
Potassium, % DM	1.03	0.92	0.81	0.71	0.60
Sulfur, % DM	0.24	0.23	0.23	0.22	0.22
Fat, % DM	3.95	4.31	4.69	5.08	5.50

Table 2-A. Dry matter analysis of finishing ration containing distillers grains.

Ingredient	As Fed, %	Ingredient DM, %	Ration DM, %
Alfalfa Hay	6.35	86.90	8.55
Cracked Corn	51.15	84.00	66.59
Wet Distillers Gr.	40.00	34.60	21.45
Finisher Suppl.	2.50	88.00	3.41

Table 3. Backgrounding rations for calves containing distillers grains.

	Ration			
Ingredient, % AF	1	2	3	4
Cracked Corn	30.49	32.26	33.28	32.74
Starter Pellets	8.50	7.00	6.00	
Grower Pellets				2.00
Wet Distillers Gr.	10.00	10.00	10.00	15.00
Corn Silage	12.00	18.00	22.00	21.00
Alfalfa Hay	39.01	32.74	28.72	29.26
Nutrient				
DM, % AF	75.78	72.75	70.72	68.67
CP, % DM	14.86	14.21	13.77	14.22
NEm, Mcal/cwt	78.77	80.45	81.56	81.92
NEg, Mcal/cwt	50.97	52.59	53.66	53.97
Calcium, % DM	0.82	0.73	0.67	0.85
Phos., % DM	0.34	0.33	0.32	0.29
Potassium, % DM	0.97	0.94	0.92	0.97
Sulfur, % DM	0.19	0.18	0.18	0.19

Table 3-A. Dry matter analysis of a backgrounding ration containing distillers grains.

Ingredient	As Fed, %	Ingredient DM, %	Ration DM, %
Cracked Corn	32.74	85.00	40.53
Grower Pellets	2.00	92.00	2.68
Wet Distillers Gr.	15.00	35.00	7.65
Corn Silage	21.00	38.10	11.65
Alfalfa Hay	29.26	88.00	37.50

Table 4. Performance of heifers that were weaned in August and developed on range (Range) compared to November-weaned heifers developed in a drylot (Drylot).

Item	Range	Drylot
Number of Heifers	33	32
Initial Weight, lb[a]	460[f]	605[g]
Final Weight., lb[b]	859	830
Average Daily Gain, lb/d[c]	1.68[f]	1.34[g]
Cycling at breeding, %	94	100
Synchronized Conception, %[d]	58	50
Final Pregnancy Rage, %[e]	91	88

[a]Weight at the beginning of heifer development treatments (weaning dates were different)
Range: 9-25-03
Normal: 12-2-03.
[b]Weight at the time both groups were moved to summer pasture together and no longer supplemented (5-18-04).
[c]Average daily gain from initial to final weight.
[d]Pregnancy during a 10-d synchronization period to natural service.
[e]34-day breeding season.
[f,g]Within a row, means with unlike superscripts differ ($P<0.05$).

Table 5. Weight and body condition score (BCS) of heifers fed distillers dried grains + solubles (DDGS) and soybean hull (SBH) treatments at 40% of the diet dry matter during the last trimester of gestation.

Item	DDGS	SBH	SEM[d]
Initial Wt, lb	1117	1130	1.37
Final Wt, lb	1249[a]	1230[b]	4.75
Wt Change, lb	132[a]	110[b]	3.76
Initial BCS[c]	5.94	5.88	0.04
Final BCS[c]	5.96	5.84	0.07
BCS Change[c]	0.02	-0.04	0.06

[a,b]Means within rows having different superscripts are different ($P < 0.01$)
[c] Body condition Score
[d] Standard error of the mean

Table 6. Dietary sulfur concentrations for dry and lactating cows supplemented with incremental levels of a co-product containing 0.4% sulfur (DM) across two dietary water sulfate concentrations.

	Lbs of Co-product Supplemented[a]		
Water Sulfate, ppm	0	4	8
	Dry Cow, Winter[b]		
500	0.20	0.23	0.27
1500	0.29	0.31	0.35
	Lactating Cow, Spring[c]		
500	0.23	0.25	0.28
1500	0.37	0.38	0.42

[a]Assuming co-product is supplemented to forage containing 0.15% sulfur.
[b]Cow assumed to be 1200 lbs, consuming 8 gallons of water/d and eating approximately 2.25% of BW (DM).
[c]Cows assumed to be 1200 lbs, consuming 15 gallons of water/d and eating approximately 2.5% of BW (DM).

Table 7. Backgrounding and finishing rations containing brewers grains.

	Ration			
Ingredient, % AF	4	5	6	7
Alfalfa Hay	2.50		4.00	2.00
Corn Silage	53.52	42.50	19.65	10.00
Cracked Corn	19.48	28.28	49.97	64.25
Wet Brewers Gr.	22.00	26.36	23.18	19.75
Grower Suppl.	2.50	2.85		
Finisher Suppl.			3.20	4.00
Nutrient				
DM, % AF	43.50	47.29	62.05	69.29
CP, % DM	12.54	12.47	13.38	13.04
NEm, Mcal/cwt	78.38	84.00	89.76	93.62
NEg, Mcal/cwt	51.46	55.82	59.92	63.15
Calcium, % DM	0.54	0.47	0.55	0.54
Phos., % DM	0.27	0.29	0.31	0.31
Potassium, % DM	0.74	0.60	0.70	0.65
Sulfur, % DM	0.15	0.14	0.19	0.19

Table 8. Weaning rations for light calves containing wheat midds.

	Ration		
Ingredient, % AF	48D	48W	48W-2
Grass/Alfalfa Hay	37.29	32.98	29.74
Corn Silage		10.00	20.00
Wheat Midds	25.00	23.00	20.00
Cracked Corn	26.71	24.52	27.78
Cane/Beet Molasses	8.50	7.00	
Starter Suppl.	2.50	2.50	2.50
Nutrient			
DM, % AF	84.78	78.96	73.84
CP, % DM	14.48	14.26	14.02
NEm, Mcal/cwt	77.17	76.90	76.34
NEg, Mcal/cwt	48.00	48.00	48.00
Calcium, % DM	0.83	0.82	0.79
Phos., % DM	0.47	0.47	0.46
Potassium, % DM	1.35	1.31	0.99
Sulfur, % DM	0.21	0.20	0.16