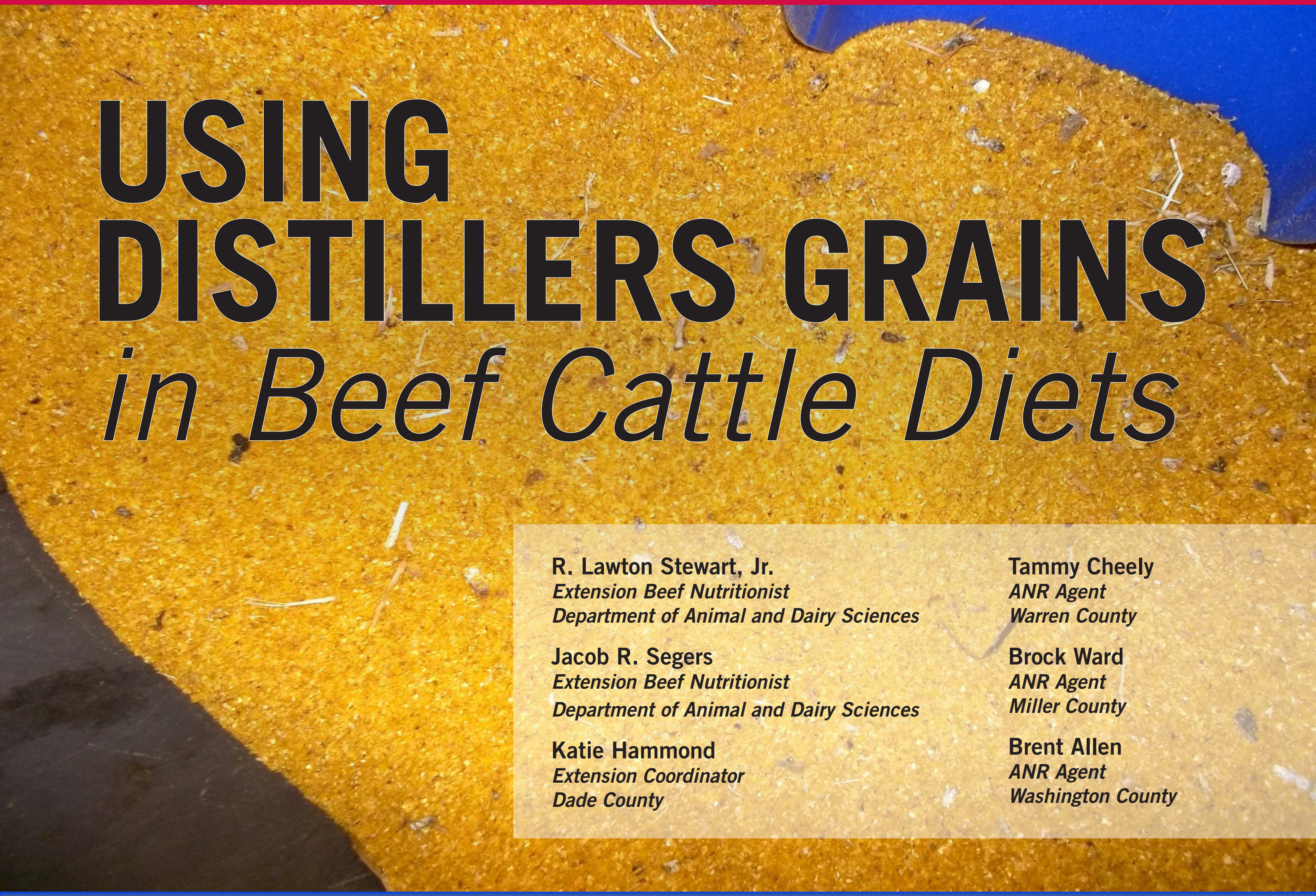

# USING DISTILLERS GRAINS *in Beef Cattle Diets*


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**Few feed ingredients have enjoyed such a pronounced increase in popularity as distillers grains.** In the early 2000s, government mandates caused the ethanol industry to greatly increase production to reach a target level of 7.5 billion gallons by 2012. This growth led to a huge increase in the construction of ethanol plants throughout the Midwest, even extending into south Georgia. The expansion of the ethanol industry was one of the driving forces behind a corresponding increase in corn prices.

As the production of ethanol increased, so did the availability of corn byproducts. Byproducts were initially considered a waste product by the milling industry. However, as production increased, the livestock nutrition industry developed a strong market for these products. Even though corn prices have moderated, distillers grains have found a lasting place in beef cattle feeding systems. Distillers grains are composed of the protein, fiber, mineral, and fat fractions of the corn kernel after the starch has been fermented to produce ethanol. In order to use these ingredients properly, producers should understand how they are produced, their characteristics, and how to formulate a ration with these products.


UGA extension

## DRY MILLING PROCESS

Grain alcohol has been manufactured for centuries, and distillers grains have been used as a feedstuff since the beginning of the 19th century. Most new ethanol plants use a dry milling process to produce ethanol. This involves yeast fermentation of the starch fraction of corn to produce ethanol and carbon dioxide. Starch comprises about two-thirds of corn, and it is fermented to ethanol in the dry milling process. Compared with corn, the process results in a three-fold increase of all other components found in distillers grain. The remaining residue is known as "whole stillage."

This high-moisture residue is centrifuged to remove a large portion of the water and soluble fraction, or "thin stillage," leaving wet distillers grains. The wet distillers grains are dried to produce dried distillers grains (DDG). The thin stillage is processed through an evaporator to remove more water, leaving the soluble fraction. The soluble fraction may be added back to the wet distillers grains and dried to produce dried distillers grains plus solubles (DDGS), sold alone as a supplement, or used to produce other feed supplements such as protein blocks/tanks. The fermentation, evaporation, and the drying processes vary greatly from plant to plant and even between runs within a plant.

These variations can cause large fluctuations in the moisture content and the nutrient availability of distillers grains. Distillers grains are available with different amounts of moisture: "wet," which is 30% dry matter; "modified wet," which is 50% dry matter; and "dried," which is 90% dry matter. These variations are derived from the drying process. If excess heat is applied during the drying process, the protein in DDG and DDGS can be heat-damaged and become bound protein. This reduces its utilization by cattle. This damage can easily be detected by visual inspection. Properly dried DDG and DDGS will have a light golden color; however, as it becomes heat damaged, it will darken in color and have a distinctive, burnt odor. Figure 1 illustrates the visual difference between an undamaged and a heat-damaged load of DDG. Analysis of load 'A,' golden in color, indicates 30.7% crude protein (CP) and 2.3% bound protein, while load 'B,' darker in color, is 26.9% CP and 9.9% bound protein. The adjusted CP, or available protein, for load 'A' and load 'B' is 28.4% and 17%, respectively. This can create protein deficiencies if not taken into consideration when balancing a ration. The price per pound of protein (described below) will increase, as well.

## USING BYPRODUCT FEEDS

Thin stillage and condensed distillers solubles are not commonly available in Georgia. When these products are available, thin stillage can be used to replace water in feeding operations due to its low dry-matter concentration. However, some cattle will not accept thin stillage as an alternative water source and require water. Many producers are attracted to the idea of using thin stillage to replace water due to its increased fiber and lipids, but there are some disadvantages. Thin stillage can build up in pipes and cause bacterial growth, so pipes must be cleaned regularly. If a producer uses thin stillage to replace water, the diet must be adjusted to account for the additional nutrients such as increased phosphorus, fat, and fiber. This can be challenging due to the variability of each shipment. Condensed distillers solubles are produced from evaporating thin stillage. If available, condensed distillers solubles may be added to cattle diets to provide additional protein and moisture.

The most common ethanol byproduct available in Georgia is DDGS. A summary of the nutrient analysis of approximately 130 DDGS samples submitted to Cumberland Valley Analytical Services (Waynesboro, Pennsylvania) from the Southeast is presented in Table 1. These byproducts can be fed as a protein source to replace other more expensive sources, such as soybean meal. The protein in DDGS is approximately 50% degradable intake protein (DIP) and 50% undegradable intake protein (UIP). Degradable intake protein, as its name implies, is broken down or degraded in the rumen by microbes. This is important to one, maintain proper forage digestion and two, produce microbial crude protein, which is used by the animal. If DIP is deficient, forage digestion will decrease. This is a common problem for operations battling forage quality issues.

Undegradable intake protein, also called bypass protein, cannot be degraded by the rumen microbes and passes to the intestine where it will potentially be utilized. If the DIP requirement is met, UIP can improve growth and reproductive performance in young cattle. In young calves, a quality source of UIP is necessary for optimal performance because DIP alone will not supply sufficient amino acids to the small intestine.

Distillers grains are also an excellent source of energy, often testing between 85% and 95% total digestible nutrients (TDN). The form of energy also makes distillers grains attractive for grazing cattle. Since the starch is removed, the energy derived from distillers

**Table 1.** Average analysis of dried distillers grains plus solubles (DDGS) samples submitted to Cumberland Valley Analytical Services (Waynesboro, Pennsylvania) from 2012 to 2017 representing the Southeastern U.S.

| Item, % of DM | Average Analysis[1] | -1SD[2] | +1SD |
|---|---|---|---|
| Dry Matter | 88.9 | 81.9 | 95.9 |
| Crude Protein | 29.3 | 26.0 | 32.6 |
| Adjusted Protein | 27.3 | 23.3 | 31.3 |
| Acid Detergent Fiber | 15.0 | 10.8 | 19.3 |
| Neutral Detergent Fiber | 34.4 | 28.6 | 40.1 |
| Lignin | 3.8 | 1.4 | 6.3 |
| Starch | 4.1 | 1.4 | 6.8 |
| Crude Fat | 10.0 | 7.5 | 12.6 |
| Ash | 5.0 | 3.8 | 6.1 |
| Total Digestible Nutrients | 84.7 | 79.3 | 90.1 |
| Net Energy Lactation (mcal/lb) | 0.91 | 0.85 | 0.97 |
| Net Energy Maintenance (mcal/lb) | 0.94 | 0.87 | 1.01 |
| Net Energy Gain (mcal/lb) | 0.64 | 0.58 | 0.70 |
| Calcium | 0.08 | -0.06 | 0.22 |
| Phosphorus | 0.83 | 0.64 | 1.02 |
| Magnesium | 0.31 | 0.24 | 0.38 |
| Potassium | 1.16 | 0.85 | 1.47 |
| Sulfur | 0.65 | 0.38 | 0.92 |
| Sodium | 0.28 | 0.07 | 0.49 |
| Chloride | 0.31 | 0.10 | 0.52 |
| Iron (PPM) | 138.0 | 44.7 | 231.0 |
| Manganese (PPM) | 23.1 | 11.5 | 34.7 |
| Zinc (PPM) | 66.3 | 53.6 | 78.9 |
| Copper (PPM) | 7.7 | 1.2 | 14.2 |

[1] Average analysis of 140 to 180 samples, depending on nutrient

[2] +/- 1 standard deviation (SD) represents approximately 67% of all samples submitted and gives an estimation of variability across samples submitted.

grains is primarily digestible fiber and fat. The digestible fiber in distillers grains complements the fiber in forages, unlike corn or other starch-based energy feeds that can depress fiber digestion. The fat content of DDGS (10% to 14%) provides energy as well. The high fat concentration is largely due to the presence of the solubles. If solubles are not added back or are de-oiled, distillers grains may only average 4% to 6% fat on a dry-matter basis. When using DDGS, fat inclusion in excess of 4% can decrease fiber digestion. However, if fed within recommended guidelines, the fat content of distillers grains should not be a problem.

## SPECIAL MINERAL CONSIDERATIONS FOR USING DISTILLERS GRAINS

The mineral content of distillers grains should also be taken into consideration. Dried distillers grain is high in phosphorus (P) and sulfur (S), but low in calcium (Ca). Supplemental Ca should be provided to balance the high phosphorus levels to maintain a Ca:P ratio above 1.5:1. If this ratio stays low for extended periods of time, urinary calculi, or "water belly," may occur. "Water belly" is a condition in which stones (calculi) block the urethra in cattle and other animals, causing the bladder to enlarge until it bursts. Excessive P excretion can also have a negative impact on water sources, increasing the risk of algal bloom.

In the milling process, sulfuric acid is used to stop the fermentation process. This adds sulfur to the distillers grains in levels that can exceed 1%. Wide ranges of S content have been reported between different ethanol plants, likely due to variations in the amount of sulfuric acid used during milling and the amount of sulfur in the water in the region. High sulfur levels in distillers grains must be monitored due to the interaction it has with other minerals. The increased sulfur levels found in distillers grains can reduce copper (Cu) absorption and contribute to a Cu deficiency. Elevated sulfur is also associated with Polio or Polioencephalomalacia in cattle. Polio, also called "brainers," is a neurological disease that presents symptoms of blindness, incoordination, staggering, and seizures in cattle. Polio was once thought to be caused solely by a thiamine deficiency, but today it is known to be caused by sulfur toxicity, lead toxicity, salt toxicity, and decreased oxygen available to the brain. The increased sulfur level in the blood of the animal interferes with cellular energy production. The brain requires a high level of energy, so sulfur levels severely affect neurological function. Careful testing should be performed to determine sulfur levels in distillers grains before feeding.

## STORAGE AND TRANSPORTATION

Dried distillers grains can be stored in a flat and dry area for an extended period of time, similar to other dried feedstuffs. Storing DDG in bulk bins can cause bridging and DDG often does not flow properly. This problem is related to the small particle size and fat content. Dried distillers grains can also be transported greater distances from the ethanol plant when compared to wet distillers grain, making DDG a more practical choice for producers that are farther from ethanol plants.

Wet and modified grains present greater storage and transportation challenges. Wet and modified distillers grains can be stored from days to several weeks depending on the temperature, air exclusion during storage, preservatives added to the feed, and the rate at which it is fed (i.e., pounds per head per day). Preservatives can extend the shelf-life of wet distillers grains, but they also add to the product cost. Due to the temperature and humidity of Georgia, wet distillers grains may only last two to three days without preservatives or special storage measures at the height of summer. One solution for storing wet distillers grains is ensiling.

Since wet distillers grains have a low pH (<4), fermentation during the ensiling process is not a concern. Wet distillers grains have been successfully preserved alone or by mixing with corn silage, beet pulp, or soybean hulls. Wet distillers grains can become moldy during transportation, therefore wet distillers grains are most practical for producers within a 30-35-mile radius of the ethanol plant. Molds and mycotoxins can also be a problem with any ethanol byproducts. The mycotoxins that affect corn are not destroyed during the production of ethanol, so they are present in the byproducts. This is more of a concern with wet and modified distillers grains in which the moisture provides a perfect environment for fungal growth and mycotoxin interaction.

## DEVELOPING A RATION

When developing a ration with distillers grains, the first factor is deciding which form to use. This decision can be affected by the location of the farm, production goals of the operation, and storage available; however, the primary consideration for most producers is the cost of available distillers grains. Due to variations in moisture, crude protein (CP), and total digestible nutrients (TDN), feedstuffs should be evaluated on a price per unit of a specific nutrient. Price can be determined by the following formula:

$$\$/\text{lb of nutrient} = \left(\frac{\$/\text{ton}}{\%\text{ dry matter} \times \%\text{ nutrient (CP or TDN)}}\right) \div 2000\text{ lbs}$$

Example: Determine cost of one pound of crude protein (CP) in a load of DDG (90% dry matter) if the load is 28% CP and costs $160/ton.

$$\$/\text{lb of CP from DDG} = \left(\frac{\$160}{0.90 \times 0.28}\right) \div 2000\text{ lbs}$$

$$\mathbf{\$/lb\ of\ CP\ from\ DDG} = \mathbf{\$0.317}$$

To avoid potential health issues, distillers grains should be limited to 30% of intake on a dry-matter basis. Dried distillers grains can be fed as a creep feed ingredient up to 50% of the diet. In stocker calves and finishing cattle, distillers grains can be fed up to 1% of body weight (e.g., 7 lb/d for a 700 lb calf). Segers et al. (2014) evaluated the utilization of DDGS at 25% of the dry matter in a corn-silage-based ration to replace ground corn and soybean meal. These authors found similar average daily gain (2.4 lb/d), but the cost of gain was lower for DDGS compared to corn and soybean meal ($51.71/cwt and $61.23/cwt, respectively). Similarly, another study (Stelzleni et al., 2016) used DDGS at 25% of the dry-matter ration to replace all soybean meal and a portion of the corn in a finishing ration. Steer gains were higher for DDGS compared to soybean meal and corn (4.3 and 3.8 lb/d, respectively), and feed conversion was improved for steers consuming DDGS compared to soybean meal and corn (6.06 vs. 6.67 lb of feed/lb of gain) This same feeding guideline is applicable for bulls. In bred heifers and cows, DDG can be incorporated in the diet anywhere from 3-5 lb/head a day. Lactating beef cows can be fed 6-8 lb of DDG/head (hd)/day.

# ON-FARM TRIAL

An on-farm trial was conducted in northeast Georgia to determine the level of intake in free-choice feeding of DDGS with tall fescue hay to developing heifers. Chemical analysis of the hay and DDG are presented in Table 2. The heifers were divided into two groups: developing heifers and bred heifers (with body weights of 590 lbs and 785 lbs, respectively). Body weights and blood samples were collected on days 1, 23, and 53 of the study. Body weight was used to monitor gain, and blood was used to monitor levels of calcium, copper, phosphorus, and blood urea nitrogen. Both groups were offered DDGS, beginning with 2 lb/hd/d. This amount was gradually increased each day to determine if heifers would self-limit intake of DDGS based on fat content. This concept would be similar to the strategy used with whole cottonseed.

By day 20, daily intake reached 12 lb/hd before the heifers self-limited intake of the DDGS (Figure 1). The free choice offering was discontinued because this level of intake can potentially cause problems due to high sulfur and phosphorus consumption. A premix containing salt, limestone, and trace mineral (Table 3) was formulated to limit intake of DDGS, and the chemical composition is presented in Table 2. These types of “hot mixes” can be used to limit intake in operations where labor and management resources are limited. The amount of premix included in the diet was adjusted on days 21 to 30, until a diet containing 85% DDGS and 15% premix limited intake of DDGS to approximately 40% of the daily dry matter intake for both developing heifers (7.8 lbs) and bred heifers (9.3 lb) over a seven-day period, as illustrated in Figure 2. This strategy would allow DDGS to be fed free-choice, provide trace minerals, maintain a Ca:P ratio above 2:1, and prevent excessive intake of DDGS. In this experiment, the mix was used in heifers, resulting in average daily gains of 1.95 lb for weaned heifers, and 1.07 lb for bred heifers (Table 4). It could serve as a potential supplement for brood cows and bulls.

The blood calcium concentration was normal throughout the feeding trial (Table 5). This would suggest that phosphorus intake was not high enough to negatively affect calcium metabolism. Copper concentration remained normal, suggesting no antagonism from sulfur. Blood urea nitrogen of developing heifers was elevated above 21 mg/dL on free choice DDG, but decreased to 18.3 mg/dL when intake was limited with the salt premix. Blood urea nitrogen above 20 mg/dL has been associated with decreased conception and pregnancy rates in cattle (Elrod and Butler, 1993). However, if DDG is fed within the recommended amount, blood urea nitrogen should not be an issue.

**Figure 1.** Comparison of two loads of dried distillers grains. Analysis of load 'A' indicates 30.7% CP, 2.3% bound protein. Analysis of load 'B' indicates 27% CP, 10% bound protein. The resulting adjusted CP for 'A' and 'B' are 28.4 and 17%, respectively. (Photo and analysis courtesy of Joe Davis Cattle Company, Westminster, South Carolina).

**Figure 2.** Voluntary dry matter intake of weaned and bred heifers fed dried distillers grains plus solubles (DDGS) with free-choice Bermudagrass hay. Heifers were fed on a step-up program to free choice (days 1-21). A salt-based premix was used on days 22-38 to limit intake.

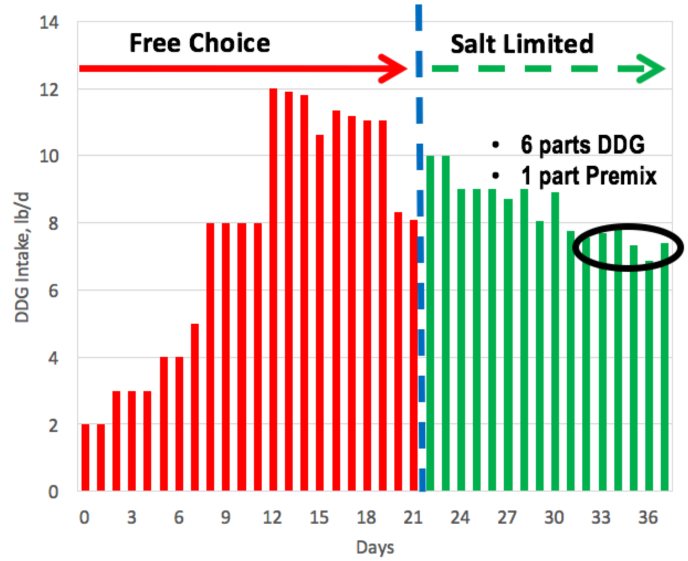


**Table 2.** Nutritional composition of Bermudagrass hay, dried distillers grains plus solubles (DDGS), and salt-based premix.

| Item, % of DM | Hay | DDGS[1] | Premix[2] |
|---|---|---|---|
| Dry matter | 89 | 90 | 98 |
| Neutral detergent fiber | 67 | 35 | 0 |
| Acid detergent fiber | 38 | 13 | 0 |
| Total digestible nutrients | 56 | 88 | 0 |
| Crude protein | 10 | 30 | 0 |
| Calcium | 0.48 | 0.10 | 10 |
| Phosphorus | 0.27 | 0.91 | 1 |
| Sulfur | 0.28 | 0.54 | 0 |
| Salt | -- | -- | 55 |

[1] DDGS were offered initially at a rate of 2 lbs/head/day and increased to free choice intake until intake reached 12 lbs/head/day, at which time premix was included.

[2] Premix was added at 10% of daily intake to limit intake of DDGS, avoiding unsafe S and P levels.

**Table 3.** Composition of salt-based premix feed with dried distillers grains plus solubles (DDGS) to limit intake, provide trace minerals, and maintain Ca:P above 2:1.

| Ingredient | Premix[1] | | Total Mixed Ration | |
|---|---|---|---|---|
| | % | lb/ton | % | lb/ton |
| DDGS | - | - | 85.00 | 1,700 |
| Salt | 60 | 1200 | 8.75 | 175 |
| Trace Mineral | 25 | 500 | 3.75 | 75 |
| Limestone | 15 | 300 | 2.50 | 50 |

[1] Percentage and pounds are rounded to simplify mixing and do not match the exact values of the total mixed ration.

**Table 4.** Body weight change, daily intake, and gain of weaned and bred heifers fed dried distillers grains plus solubles (DDGS) and a salt-based premix.

| Weaned Heifers | Day 0 | Day 23 | Day 52 |
|---|---|---|---|
| Weight, lb | 580 | 613 | 672 |
| DDGS[1], lb Intake | -- | 7.5 | 8.5 |
| Premix[2], lb Intake | -- | -- | 1.1 |
| ADG, lb/day | -- | 1.62 | 1.95 |
| **Bred Heifers** | **Day 0** | **Day 23** | **Day 52** |
| Weight, lb | 785 | 794 | 826 |
| DDGS[1], lb Intake | -- | 7.5 | 8.4 |
| Premix[2], lb Intake | -- | | 1.2 |
| ADG, lb/day | -- | 0.41 | 1.07 |

[1] DDGS were offered initially at a rate of 2 lbs/head/day and increased to free choice intake until intake reached 12 lbs/head/day, at which time premix was included.

[2] Premix was added at a 10% of daily intake to limit intake of DDGS, avoiding unsafe S and P levels.

**Table 5.** Blood urea nitrogen (BUN), copper (Cu), Calcium (Ca), and phosphorus (P) concentration from weaned and bred heifers fed dried distillers grains plus solubles (DDGS) and a salt-based premix.[1]

| Weaned Heifers | Day 0 | Day 23 | Day 52 |
|---|---|---|---|
| BUN | 13.0 | 21.5 | 18.3 |
| Cu | 0.69 | 0.92 | 0.87 |
| Ca | 85.4 | 104.7 | 105.0 |
| P | 5.4 | 4.4 | 6.1 |
| **Bred Heifers** | **Day 0** | **Day 23** | **Day 52** |
| BUN | 13.4 | 19.0 | 21.6 |
| Cu | 0.56 | 0.79 | 1.1 |
| Ca | 101.5 | 105.7 | 106.6 |
| P | 6.5 | 4.9 | 6.2 |

[1] DDGS were offered initially at a rate of 2 lbs/head/day and increased to free choice intake until intake reached 12 lbs/head/day at which time premix was included at 10% of daily intake to limit intake of DDGS, avoiding unsafe S and P levels.

# SUMMARY

The future of the feed industry and ethanol production is unclear and ever-changing. Distillers grains have become a staple feed for many different types of cattle operations. Despite limitations with sulfur, phosphorus, and fat, distillers grains offer producers an additional option for protein and energy supplementation when cost is not prohibitive. It is recommended that distillers grains be regularly tested for nutrient concentration and percent dry matter. For assistance developing beef cattle rations using distillers grains, please contact your local Extension office at 1-800-ASK-UGA-1 or extension.uga.edu.

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