FEED MANUFACTURING CONSIDERATIONS FOR USING DDGS IN POULTRY AND LIVESTOCK DIETS

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Summary

While not a new ingredient in livestock feed, the volume available and the relative price of DDGS have forced many feed manufacturers into using greater levels than ever before. The use of DDGS has caused feed manufacturing problems at nearly every phase of feed manufacturing. These include railcars that simply won't unload, feeder screws and supply bins that are wrong for the ingredient, nutrient variation that results in out-of-spec feeds leaving the feed mill, and, of greatest concern, pellet throughput and pellet quality concerns. Nearly all of these problems are the result of the physical properties of DDGS and of the way a particular ethanol facility might manage their byproducts.

There is little doubt that the ethanol industry will continue to grow, displacing feed corn with DDGS and other byproducts. It is imperative that we learn to deal with these byproducts effectively so that we can produce the highest quality feeds possible.

Introduction

Dried distillers grains (DDGS), in one form or another, have been used in compound feeds or as livestock feeds for nearly a century. Early on, of course, the distillers grains came from the beverage alcohol industry and were a very minor ingredient available on a regional basis. Things have certainly changed and everybody is trying to "get into the game."

What this has meant to the livestock industry is a significant increase in grain prices and in the availability of DDGS. Nutritionists in all livestock areas are scrambling to keep feed costs as low as possible while keeping the desired performance in efficiency and growth rate.

Historically, DDGS have been used primarily in ruminant diets. While that is still true today, DDGS are finding their way into poultry and swine diets at an ever-increasing level. As is always the case, the introduction of a previously unused ingredient is not without frustration at most feed mills. The purpose of this paper is to identify some of the issues that have been identified and to discuss ways in which the resulting problems can be addressed.

Feed Mill Issues with DDGS

Bin Space Allocation

Anytime a new ingredient is introduced into a feed mill, the first issue to be dealt with is bin and storage space allocation. It is seldom that the feed mill will have an open bin above the major ingredient scale that can be assigned to the new ingredient. When making bin assignments, the minimum information needed by the manager would include the expected usage rate (pounds per ton), physical properties such as density and flow characteristics, and an estimate of how long the ingredient will be used, in the case of seasonal ingredients.

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In many feed mills, there is simply no way to open a bin for a new ingredient without significantly disrupting production. In these cases, the best solution is to discontinue using an existing ingredient and designate the former ingredient bin for the new ingredient. However, if the bin volume, hopper configuration, and feeder screw design are not compatible for use with the new ingredient, further “re-arranging” will be necessary. For example, let’s assume that DDGS is coming into the feed mill and “Phu Phu” meal is being discontinued. Phu Phu meal is fairly heavy at 60 lbs/ft^3 while DDGS is fairly light at 30 lbs/ft^3. Assuming nothing is changed, it will take twice as long for the same weight of DDGS to be delivered as it took for the Phu Phu meal. The obvious question is can the batching cycle be extended without a negative effect on the mixing cycle?

Receiving and Storage

One would have to live in a cave to not have heard horror stories about receiving and unloading railcars of DDGS. Because of very limited storage at ethanol sites, DDGS are often loaded directly from the dryer onto railcars. In most ethanol plants, the solubles are condensed to about 50% DM, and then sprayed onto the grains just before entering the dryer. While, on average, the moisture content of the DDGS is appropriate (<11%) for shipping and storage, the likely variation within the mass is substantial. Because of the water binding capacity of the solubles, it is likely that they will be at 15-18% moisture while the fermentation solids (fiber, protein, and yeast) are below the 10-11% target. When blended, the internal moisture will equilibrate but not before serious bridging can occur.

At this point in time, anti-caking agents, such as those used in soybean meal, are not approved for use in DDGS and there is probably some question as to how well they would work in this application.

The real culprit in DDGS causing the arch-formation, in addition to the solubles in DDGS, is the flat, plate-like structure of the bran particles. Soybean meal has a very similar shape as a result of the flaking process prior to solvent extraction.

There are several approaches that can improve the flow characteristics of DDGS. Unfortunately, the two most logical must occur at the ethanol site. The first is to simply hold the DDGS in storage onsite until moisture equilibration occurs. In most cases, that would be five to seven days. After equilibration occurs and the “matrix” is broken, bridging and arch-formation are unlikely to occur in normal transportation systems.

The second approach would be to pellet the DDGS (Bauer and Clark, 2004). In this experiment, DDGS were pelleted using various conditioning temperatures and die sizes to determine the ease of pelleting and to evaluate the physical properties and flow characteristics of the resulting product. The results of the study would indicate that nearly any level of agglomeration improved the flowability of DDGS. If this approach is ultimately adopted by the ethanol industry, there will be costs passed on to the ingredient buyer for the pelleting. In addition, if a good quality pellet were produced, grinding at the feed mill would be required thus adding cost to the ingredient.

However, there are real costs to the feed mill in labor and receiving system downtime while trying to unload a bridged railcar. In addition, worker safety must be considered as well. Without significant changes at the source of the DDGS, the feed industry will have to find ways, other than the sledgehammer approach, to efficiently unload railcars of DDGS. In several California feed mills, where 20 plus railcars of DDGS arrive at a time, a stationary device is mounted above the rail pit that is used to drive a spear down through the grains to break the bridge. The device is essentially a backhoe equipped with a 10' to 12' pipe “spear.” While the device is effective at unloading a railcar in a reasonable amount of time, additional labor, capital, and operating expenses are obviously necessary.

It appears that, once the moisture is equilibrated and the initial arch-formations are destroyed, DDGS will flow well within the feed mill systems.

Variation

While nutrient variation is not directly a feed manufacturing problem, it becomes an issue when quality control sample assays come back out of tolerance and the feed mill operators are called on the carpet. In 2004, nutritional scientists with the Degussa Corporation published a summary of assay results for 51 samples of DDGS from various ethanol plants in the U.S. Crude protein (CP) content of these samples ranged from a low of 25.1% CP to a high of 31.1% CP with an average of 27.5% CP and CV of 5.1%. At a use level of 5% (100 lbs/ton), this degree of variability would result in a protein difference of 0.177% CP in the final feed. In today's world, nutritionists are often pushing the level of inclusion to 10 to 12%, and, because of demand, the ingredients are coming from several ethanol plants over a wider geographical area. Both of these factors could result in greater nutrient variation in finished feeds. At the 2006 Mid-Atlantic Nutrition Conference, data presented by Fiene *et al*. (2006) documented the variability in predicted lysine digestibility in DDGS from eight different sources. The mean predicted digestibilities ranged from 56.9% to a high of 72.2%. From the data, it was obvious that some suppliers were doing a much better job of controlling their processes than others with a high range of nearly 28% (67.5% AV, 27.8% range) and a low range of just 3.9% (72.2% AV, 3.9% range).

The obvious question is what can be done at the feed mill level to "smooth" the inherent nutrient variability? The first answer is based on the implication above in that, if an ingredient is sourced from a single supply point (i.e., ethanol facility in the case of DDGS), the nutrient variation and other quality attributes are usually lower than if multiple suppliers are used. In most cases, feed mill managers have little influence over purchasing decisions. However, if the feed mill is doing a good job of sampling and tracking suppliers, careful analysis of the data may reveal patterns that, when properly presented, can influence purchasing decisions. Don't expect your purchasing department to do the data analyses. They typically focus on one thing only and that is "price delivered."

Tracking nutrient variation in feed ingredients is not a new concept. Deyoe (1964) published an extensive data set regarding ingredient variation and its effect on animal nutrition. Knowing that variations exist and actually being proactive in doing something about it are two different things. Chung and Pfost (1976) address the issue of overcoming ingredient variation in the feed mill. The two major techniques discussed rely on having a good sense of the existing or potential variation in critical nutrients for a specific ingredient.

The useful technique discussed involves blending several lots of an ingredient so that each lot is equally represented in any sample taken. If this can be done, then:

0 = m (the new average for the blend is equal to the average of all lot means)

and: $\bar{s} = \frac{s}{\sqrt{n}}$ where "$\bar{s}$" is the new blend standard deviation, "s" is the old standard deviation of the individual lots prior to blending, and "n" is the number of lots blended.

It is obvious that this type of blending can take place only in facilities equipped to do so. For example, a grain terminal, where ingredients can be drawn from numerous storage bins simultaneously, would be ideal.

The second procedure is much more practical and involves simply segregating an ingredient into two separate storage facilities based on a lot being "above" or "below" a predetermined value (e.g., historical average). By segregating, it can be shown that:

$$\overline{x_{high}} = m + \frac{\sqrt{2}}{\sqrt{\pi}} \bullet S$$

and

$$\overline{x_{low}} = m - \frac{\sqrt{2}}{\sqrt{\pi}} \bullet S \text{ and } \overline{S} = 0.603S.$$

When this is done, it is a simple matter for the nutritionist to formulate rations using the same ingredient with two different nutrient values by treating them as different ingredients. For example, if we segregated corn based on an average of 7% with an S of .75%, then we would have a supply of corn with an average of 7.6% (SD = 0.45%) and a supply of 6.4% (SD = 0.45%). In the above example, the only costs involved are the labor and management involved in inventorying two ingredients instead of one. Of course, a way to quickly analyze for the attribute being used as the basis for segregation is needed, but many feed mills already have an NIR available for rapid testing of moisture, protein, and oil.

While the use level of DDGS, at this time, may not be sufficient to justify implementing the above procedure, it is equally useful for grain and protein meals as well and can represent the next level of management skills needed in modern mills.

Pelleting and Pellet Quality with DDGS

It is likely that the biggest issue in feed manufacturing with DDGS is the effect on pellet throughput and pellet quality. Unfortunately, there are few publications and scientific articles written on this subject and the majority of information is antiquated in nature. It is pretty well accepted that, when the level of DDGS in the formula exceeds 5-7%, pellet throughput, together with pellet quality, will suffer. The questions that need to be addressed are: why does this happen and what can be done to correct the problem?

It is unusual that pellet quality is reduced as pelleting rate is decreased. When throughput is reduced and if nothing else changes, pellet quality usually increases. That is due primarily to the increased time a given pellet stays in the die hole where the bonds that hold particles together are formed. It has been documented (Behnke and Beyer, 2002) that starch is usually involved in the bonding between particles that results in strong durable pellets. The fact that there is little starch in DDGS that can be gelatinized and made into an adhesive contributes to poor particle bonding. In addition, DDGS are relatively high in oil compared to the grain and protein meal it replaces. Again, the bonds between particles in the pellet are affected because they are primarily hydrophilic in nature. If sufficient oil is present to coat the particles to some extent, the hydrophobic nature of the coating inhibits bonding between starches, proteins, and the like.

As to the throughput issue, this is the feed manufacturing version of the “perfect storm.” Because of environmental concerns, many feed mills have essentially stopped using dicalcium phosphate (dical) or deflorinated phosphate (deflor) as a mineral in formulas. Instead, the enzyme phytase is included to improve the availability of organic phosphorus. It has long been recognized that either mineral, but particularly deflorinated phosphate, contributes to increased pelleting rate. It is accepted that the minerals contribute an abrasive character to the feed thus “polishing” the surface of the die holes, therefore, reducing the level of friction between the pellet and the die hole surface.

It is theorized that solubilized protein and/or crystalline starch go through what is known as a “glass transition” and are essentially burned onto the die hole surface. Even though the pellet mash and pellets are about 180-190°F, the die itself is likely about 300°F which is sufficient to cause the glass transition of proteins and essentially bond the protein to the die hole surface.

It is likely that the culprit in DDGS is the corn protein, zein. The processes of grinding, fermentation, and distillation frees this insoluble protein and it certainly is concentrated relative to the level in ground corn.

As to the question of what to do about it, there are no easy answers. One might be tempted to use a thinner die which would allow increased throughput. However, there would also be a negative impact on pellet quality which is already an issue.

Some feed mills have found it useful to use fine silica sand in some formulas to "re-condition" the die periodically. If used, the particle size of the sand should be approximately the same as defluorinated phosphate to be effective at scouring the die. The most convenient approach would be to select a formula that is run fairly often (e.g., every two hours) and simply include sand as an ingredient.

Using an ingredient, such as sand, in a commercial feed presents a rather special problem due to required labeling. Imagine the reaction of a feed purchaser when reviewing the ingredient list and finding the word "sand." One might choose to use the words "silica" or "silicon dioxide" instead of sand.

As to the future in dealing with pelleting issues related to higher levels of formula DDGS, there are several possibilities. It may be that the die manufacturers can help with more appropriate alloys. There is no doubt that the DDGS themselves will change as the ethanol industry evolves. Several of the newer facilities are being designed with "front-end" fractionation. This topic will be discussed by another speaker at the Conference so will be only briefly discussed here.

Essentially, front-end fractionation involves removing most of the bran and germ prior to grinding and conversion of the starch to sugar. What this will mean is that the DDGS will be substantially higher in protein and lower in oil and fiber. There is no doubt that this will result in changes at the pellet mill that will be as dramatic as when DDGS first found their way into swine and poultry diets.

Conclusion

While not a new ingredient in livestock feed, the volume available and the relative price of DDGS have forced many feed manufacturers into using greater levels than ever before. The use of DDGS has caused feed manufacturing problems at nearly every phase of feed manufacturing. These include railcars that simply won't unload, feeder screws and supply bins that are wrong for the ingredient, nutrient variation that results in out-of-spec feeds leaving the feed mill, and, of greatest concern, pellet throughput and pellet quality concerns. Nearly all of these problems are the result of the physical properties of DDGS and of the way a particular ethanol facility might manage their byproducts.

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