Water Activity for Monitoring the Quality of Dried Distillers Grain

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Dried Distillers Grain with Solubles (DDGS) is a co-product of the grain bio-ethanol manufacturing process. It is created through a multi-step process. First, the non-fermentable material leftover from ethanol production is removed as stillage. Excess water is removed from the stillage by centrifugation and the wet grains are combined with condensed distillers solubles and dried to create DDGS. It is sold primarily as a high quality feed supplement, but could potentially have many uses including as a nutritional supplement for humans. The sale of DDGS contributes substantially to the economic viability of an ethanol production plant. Consequently, optimization of DDGS quality and shelf life are of utmost importance.

Recommended Analytical Methods for DDGS

On February 1, 2007, the American Feed Industry Association released a study titled "Evaluation of Analytical Methods for Analysis of Dried Distillers Grains with Solubles." This study examined analytical method efficacy for evaluating DDGS. The objectives of the study were to choose a set of tests that would best characterize the physical and chemical characteristics of DDGS and ensure its safety and quality. The main concerns for DDGS shelf life are susceptibility to microbial degradation, maintaining flow properties, and moisture migration.

Water influences all of these concerns. In this study, the only moisture analysis method listed was moisture content. Unfortunately, moisture content is not the most effective moisture analysis method for the concerns listed above. Water activity is a better predictor of microbial safety, flow properties, and moisture migration. Ethanol producers will have more success ensuring the quality of their DDGS product while saving time and money if they use water activity as one of their quality assurance tests.

What is Water Activity?

Water activity represents the energy status of the water in the system and is equal to the relative humidity of the air in equilibrium with a sample in a sealed chamber. It is based in thermodynamics and is defined as the vapor pressure of water (p) over a sample divided by the vapor pressure of pure water (p_o) at a given temperature. Though not scientifically correct, it may help to picture water activity as the amount of "available" water in DDGS. It is not determined by how much water is present in DDGS, but is a comparison of how much the water in DDGS resembles and behaves like pure water.

Water activity values represent a scale that ranges from 0 (bone dry) to 1.0 (pure water). As water activity decreases, the water in DDGS decreases in energy, is less available, and behaves less and less like pure water. For example, a water activity of 0.80 would indicate that water in the system has enough energy to support mold growth while a water activity less than 0.60 means that the water in the system cannot support the growth of any microorganisms. Water also becomes more mobile as water activity increases, which influences molecular mobility and increases chemical and enzymatic reaction rates. For example, browning reactions rates will be minimal at a water activity of 0.25, steadily increase as water activity increases, and reach a maximum at about 0.80 a_w.

Water Activity Controls Microbial Growth

The water activity concept has served microbiologists and food technologists for decades and is the most commonly used criterion for food safety and quality. Microorganisms have a limiting water activity below which they cannot grow. Water activity, not moisture content, determines the lower limit of "available" water for microbial growth. Since bacteria, yeast, and molds require a certain availability of water to support growth, drying DDGS below a critical a_w level provides an effective means to control microbial growth. Water may be present, even at higher content levels than normally acceptable in DDGS, but if its energy level is sufficiently low, the microorganisms cannot utilize the water to support their growth. This 'desert-like' condition creates an osmotic imbalance between the microorganisms and the local environment. Consequently, the microbes become dormant or die. The water activity level that limits the growth of the vast majority of pathogenic bacteria is 0.90, a water activity of 0.70 is the limit for spoilage molds, and the lower limit for all microorganisms is 0.60.

Water Activity Helps Control Caking, Clumping, Collapse and Stickiness

Water activity can also be an indicator of physical stability of DDGSs during storage. Due to its impact on ease of handling, flowability is a major physical stability concern for DDGS. Controlling water activity in DDGS maintains proper structure, texture, stability, and density. A critical water activity can be identified below which DDGS will maintain its flow properties. Above this critical water activity, the DDGS particles are wetted and begin to stick together. Consequently, knowledge of the water activity of DDGS as a function of moisture content and temperature is essential during processing, handling, packaging and storage to prevent the deleterious phenomenon of caking, clumping, collapse and stickiness. Water activity is the most effective rapid quality assurance test available to assess the susceptibility of DDGS to experience reduced flow properties.

Water Activity Controls Moisture Migration

Because water activity is a measure of the energy status of the water, differences in water activity are the driving force for moisture migration. Knowledge of whether water will absorb or desorb from within a load of DDGS is essential to prevent degradation. Thus, water activity is an important parameter since it can control water migration in mixed lots of DDGS. By definition, water activity dictates that moisture will migrate from a region of high a_w to a region of lower a_w, but the rate of migration depends on many factors.

Different loads of DDGS could have different water activities due to variation in drying conditions and amount of added solubles. If loads of DDGS with different water activities are combined for storage or transport, regardless of their moisture contents, moisture will exchange until they have the same water activity. For example, if equal amounts of one load of DDGS at 15% moisture and a second load at 15% moisture content are blended together, will there be moisture exchange between the loads? The answer depends on the water activities of the two loads. If the water activities of the two loads are the different, then moisture will be exchanged, even though their moisture contents are the same. This moisture migration could lead to flow or microbial growth problems.

Conclusion

Water activity is an effective process control and quality assurance tool for maintaining the stability and safety of DDGS and should be included as a recommended analytical method for DDGS. In addition to the reasons outlined above, water activity is a more effective moisture analysis than moisture content because it is more sensitive and accurate. In the intermediate moisture region, which includes DDGS, changes in moisture content that are undetectable due to the limited accuracy of moisture content analyses can result in large changes in water activity and consequently, changes in stability. This can be disconcerting when DDGS are dried to a moisture content specification and stability changes suddenly occur even though a moisture content change is not detected. These stability changes can be predicted if a water activity specification is used. Water activity is a fast, inexpensive, and accurate way of assuring the quality and safety of DDGS. It can easily be incorporated by any ethanol plant. If interested in learning more about water activity testing and DDGS, please contact Decagon Devices, Inc.

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