CHAPTER 8

Comparison of Nutrition and Quality Differences Between China vs. U.S. DDGS Sources

Introduction

IN RECENT YEARS, CHINA HAS BEEN THE LARGEST IMPORTER OF U.S. DDGS. Fabiosa et al. (2009) reported Chinese feed mills realized a 6 percent reduction in feed costs by using imported U.S. corn DDGS as a partial substitute for soybean meal and corn and other more expensive ingredients. No data are available on the total amount of Chinese DDGS produced annually, but the total DDGS production from five officially designated Chinese plants was 1.69 million MT in 2010 (Jewison and Gale, 2012). Using 2011 data from the China Ministry of Agriculture Feed Industry Office, Jewison and Gale (2012) indicated swine consumed the majority (37 percent) of DDGS, followed by layers (29 percent), broilers (19 percent) and aquaculture (9 percent), whereas ruminants and other consumption represented only four and two percent, respectively.

In 2014 to 2015, China was the world's largest importer of soybeans, rapeseed, DDGS, sorghum, barley and fish meal for use in animal feeds (Gale, 2015). In addition, China is the world's largest food animal producer and manufacturer of animal feed (Gale, 2015). As the human population continues to increase in China, and the consumption of animal derived food products continues to increase, the demand for many imported ingredients, such as DDGS, will continue to increase. However, Jewison and Gale (2012) indicated the demand for U.S. DDGS in China in the future will depend on several factors including the price of corn, soybeans and soybean meal; Chinese government policy, including the recent reforms to the corn support price and official reserve systems; and the price and availability of other substitute feed ingredients. In addition, China's demand for domestic and imported feed ingredients to support its expanding livestock and poultry industries is expected to continue to increase significantly.

Approximately, 66 percent of total U.S. DDGS production is consumed by U.S. beef (45 percent), dairy (31 percent), swine (15 percent), poultry (8 percent) and other (1 percent). Future U.S. DDGS consumption will depend on the price and availability of competing or substitute ingredients such as corn and soybean meal. When the price differential is in favor of DDGS, more of it will be used to replace corn and/or soybean meal in animal feeds. During the last 12 months (July, 2015 to June, 2016) the U.S. spot price for DDGS has ranged from 86 to 115 percent the price of corn, 37 to 50 percent the price of soybean meal, and the cost per unit of protein has been consistently less for DDGS compared to soybean meal (difference ranged from about $0.37 to $2.54 per unit of protein). This protein price advantage for DDGS has made it more competitive as a partial protein substitute in animal feeds compared with soybean meal in the U.S. feed market.

Very little growth in ethanol and DDGS production is expected in the U.S. over the next several years, unless government policy changes are implemented to increase ethanol production. However, this is not expected to occur. Most of the changes that have and will occur in the U.S. ethanol industry are those to create more value from the production of more diversified of co-products. Minor capital expenditures have been made to extract distillers corn oil in the majority (85+ percent) of U.S. ethanol plants. Other minor to modest capital expenditures will be made by some ethanol plants to implement other new ethanol and co-product production technologies. These technologies will result in the production of low-oil (less than 6 percent) DDGS, distillers corn oil, corn fiber for producing cellulosic ethanol, production of high protein DDG or high fiber DDGS, along with a few other specialty co-products.

Differences in DDGS Production Processes

There is very limited published information about Chinese beverage, fuel ethanol and DDGS production processes. However, it is well established that energy and nutrient composition and digestibility of DDGS are affected by several factors including type of grain used, nutrient composition of these feedstocks, as well as various beverage and fuel ethanol and co-product processing methods (Ingledew et al., 2009).

Differences in feedstocks

The feedstocks used to produce ethanol and DDGS are different between U.S. and Chinese ethanol plants, but no data are available on the total amount, type and proportion of feedstocks used to produce Chinese DDGS. Jewison and Gale (2012) said there were five officially designated Chinese ethanol plants in 2010, which used corn, wheat and cassava as feedstocks to produce 1.69 million metric tons of DDGS (4.5 percent of total U.S. corn DDGS production). The beverage alcohol industry in China increased rapidly in the 2000's, but feedstocks used to produce ethanol in China vary by geographical region and include corn, rice, wheat, sorghum, potatoes and cassava (Gale et al., 2009).

Beverage alcohol production often involves using blends of grains, whereas fuel ethanol production in the U.S. involves primarily using corn as a sole feedstock. A few U.S. ethanol plants use sorghum or corn-sorghum blends as feedstocks, but the DDGS produced from these plants is marketed and consumed domestically. Furthermore, only about one to two percent of total DDGS production in the U.S. is derived from beverage alcohol plants, which is presumed to be much less than in China. It appears most of the corn-based fuel ethanol and co-product production in China occurs in the northeast region where the majority of corn is produced. However, although there are no data on the quantities of co-products produced from various types of beverage and fuel ethanol plants in China, it appears corn co-products are the most abundant.

Differences in production processes and nutrient content of DDGS

Fuel ethanol plants in the U.S. use more advanced production technology to produce ethanol and DDGS than those used in China. Most of U.S. ethanol plants were built after 2004 and much of the equipment installed in these plants consists of stainless steel. Ease of cleaning and maintaining high sanitation in ethanol plants is critical for preventing bacterial infections during ethanol fermentation. In contrast, Chinese ethanol plants using corn as a feedstock were built using carbon steel that corrodes easily, allowing bacterial infections to frequently occur during fermentation, which can cause incomplete fermentation, reduced ethanol yields and suboptimal quality of DDGS. Furthermore, corrosion of carbon steel in Chinese ethanol plants has led to extremely high iron content (500 to 1,700 ppm) in DDGS, compared to iron concentrations in U.S. DDGS (120 to 150 ppm). While this may be of minor concern relative to DDGS feeding value, it likely contributes to the darker color of Chinese DDGS.

The majority (over 90 percent) of U.S. ethanol plants are partially extracting oil prior to manufacturing DDGS. Although one of the major ethanol companies (n = 27 ethanol plants) produces DDGS containing 4.5 to 5.0 percent crude fat (as-fed basis), the majority of the U.S. ethanol industry produces DDGS containing a minimum of seven percent crude fat to as much as 14 percent crude fat on an as-fed basis. In contrast, Li et al. (2015) reported that among 25 samples collected from Chinese beverage and fuel ethanol plants, about 44 percent of these samples contained less than six percent crude fat on an as-fed basis. In another recent study, (Jie et al., 2013), obtained 28 corn DDGS sources from several ethanol plants in 11 provinces in China and two corn DDGS samples produced in the U.S. that were imported into China. The range in crude fat content (as-fed basis) was from 1.43 to 15.1 percent, with 32 percent of these samples containing less than six percent crude fat. In contrast, the two U.S. DDGS samples analyzed in this study contained 12.1 and 13.6 percent crude fat. Kerr et al. (2013) evaluated the energy value and chemical composition of 15 corn DDGS sources produced in the U.S. Oil content ranged from 4.3 to 11.2 percent (as-fed basis), but only two samples (13 percent) contained less than six percent crude fat. In summary, it appears that one of several major distinguishing differences between Chinese and U.S. DDGS is that there is a greater proportion of low-oil (less than 6 percent crude fat) DDGS being produced in China than in the U.S.

A recent study published by Li et al. (2015) evaluated the energy value and chemical composition of 25 DDGS samples collected from 17 Chinese beverage (18 samples) and fuel (seven samples) ethanol plants. Therefore, based on the high proportion of DDGS samples collected from the beverage ethanol industry, this is further evidence one of the distinguishing differences between Chinese and U.S. DDGS is that the majority of Chinese corn DDGS is produced by the beverage alcohol industry. Li et al. (2015) classified Chinese DDGS samples into five categories of based on crude fat composition (dry matter basis) and types of processing used:

1. High-oil (9.6 to 13.9 percent crude fat) DDGS (13 samples)

2. Added hull high-oil (8.7 and 9.9 percent crude fat; two samples)

3. Partially reduced-oil (6.6 percent crude fat; one sample) DDGS

4. Reduced-oil DDGS with part of the germ removed (5.1 percent crude fat; one sample)

5. "Common" reduced-oil DDGS (2.82 to 4.9 percent crude fat; eight samples).

These classifications imply there is much more variation in production processes used in Chinese ethanol plants than those used in U.S. fuel ethanol plants, with the common feature of partial oil extraction. However, if the samples collected in the Li et al. (2015) study are indicative of the proportion of Chinese ethanol plants extracting significant amounts of oil, it appears there is significantly more low-oil (less than 5 percent crude fat, dry matter basis) in Chinese DDGS than for U.S. DDGS.

Xue et al. (2012) compared three samples of Chinese corn DDGS produced in Shandong, Jilin, and Hebei provinces with one sample of Chinese DDGS produced from rice with bran, and two U.S. corn DDGS samples (conventional and high-protein). The rice DDGS sample had the lowest crude fat and gross energy content, and the highest crude fiber content of all samples. The Chinese corn DDGS samples had higher acid detergent fiber (ADF) content than the conventional U.S. corn DDGS sample, and lower lysine content. These researchers also reported that the lysine to crude protein ratio in Chinese corn DDGS was lower (1.93 percent) compared to U.S. corn DDGS (2.87 percent). This implies that lysine digestibility of the Chinese DDGS sample would be lower than the U.S. DDGS sample. A higher fiber, lower gross energy, and lower lysine content are key indicators of reduced feeding value of Chinese DDGS for swine and poultry, compared with the U.S. DDGS source evaluated in this study. However, the limited number of samples evaluated by Xue et al. (2012) showed there was no significant difference in metabolizable energy (ME) content between the three Chinese corn DDGS sources (3,306 kcal/kg) compared with the conventional corn DDGS source from the U.S. (3,525 kcal/kg), even though the U.S. sample numerically had 219 kcal/kg greater ME content than the average of the three Chinese DDGS sources. Furthermore, the average standardized ileal lysine digestibility of the Chinese corn DDGS samples was lower (52 percent) compared with conventional U.S. DDGS (57 percent) and U.S. high protein DDGS (60 percent).

Differences in production processes and DDGS color

The color of DDGS has become a quality factor of great importance for some buyers in the export market, and it is being used to differentiate real or perceived quality and value among DDGS sources. The color of DDGS is correlated with several nutritional components and physical characteristics. In some cases, a light colored DDGS source may infer higher lysine digestibility, xanthophyll content, and minimal lipid oxidation. On the other hand, darker colored DDGS sources may have higher concentrations of other nutrients compared with lighter colored sources. For example, adding increasing levels of solubles to the coarse grains fraction when producing DDGS sources results in higher energy, crude fat, and mineral content, with minimal effects on crude protein and amino acid content and digestibility, compared to lighter colored sources containing less solubles. Furthermore, darker colored samples appear to have higher relative phosphorus bioavailability for poultry. Particle size, moisture content and other physical properties of DDGS are also correlated with color, but the value of these relationships is more difficult to assess from a feed manufacturing and nutritional perspective.

Several years ago, some DDGS marketers and buyers developed a subjective color evaluation system using a five-color scoring card (**Figure 1**) to differentiate color among DDGS sources.

Although this DDGS color score card is still used in the market today, many marketers have stopped using it because it is too subjective and resulted in frequent arguments with buyers because of different interpretations of the actual color score of DDGS. As a result, many marketing contracts currently being negotiated between U.S. suppliers and foreign buyers (especially in Asian countries), contain a minimum guarantee for a quantitative measure of color (e.g. L* - lightness or darkness of color). The minimum guarantee currently being used to differentiate lightness of DDGS color is a Hunter L* greater than 50. However, increasing amounts of U.S. DDGS continue to be exported to various countries regardless of color, but for some markets demanding a guarantee of light colored DDGS (i.e. L* greater than 50), there is a significant price premium obtained for those marketers who can guarantee an L* greater than 50 in the DDGS sources they market.

Use of different production and drying processes between U.S. and Chinese ethanol plants has also led to differences in color (**Figure 2**). Color of DDGS U.S. DDGS generally has a lighter, golden color, which is preferred by Chinese buyers because color is considered to be a subjective indicator of greater protein and amino acid digestibility and feeding value. In fact, color is so important to some Chinese buyers that they often request a minimum guarantee for light color (L* greater than 50) in their marketing agreements. Chinese DDGS tends to be darker in color, which infers less nutritional value.

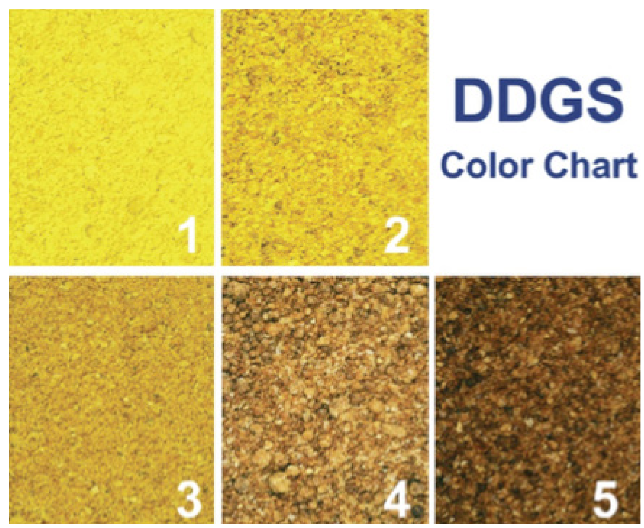

Figure 1. Example of a DDGS color score card

Figure 2. Color comparison between U.S. DDGS (left) and Chinese DDGS (right)

Jie et al. (2013) obtained 28 corn DDGS sources from several ethanol plants in 11 provinces in China and two corn DDGS samples produced in the U.S. imported into China. These researchers measured the lightness (L*), redness (a*) and yellowness (b*) of color of these samples using a HunterLab colorimeter. A low L* color score (scale of 0 to 100) indicates a darker color and L* and b* have greater correlations with lysine and amino acid digestibility (which have been used as general indicators of nutritional value) than a*. The L* values for the 28 Chinese DDGS sources ranged from 30.9 to 59.5, a* ranged from 14.6 to 27.7 and b* ranged from 35.3 to 59.8. Although only two U.S. DDGS samples were evaluated in this survey, the L* scores were 54.6 and 57.3, a* scores were 18.4 and 19.7 and b* scores were 53.3 and 55.3. Only five of the 28 Chinese DDGS samples had L* scores greater than 50, whereas both of the U.S. DDGS sources had L* scores greater than 50, indicating lighter color. Furthermore, b* value of the two U.S. DDGS sources were 53.3 and 55.3 compared with only five Chinese DDGS sources that had b* values greater than 50. Urriola et al. (2013) reported that the average L* value among 34 U.S. corn DDGS sources was 52.7 and L* values can be as high as 62.5. Therefore, another distinguishing feature of U.S. DDGS compared with the majority of Chinese DDGS sources is that U.S. DDGS sources are generally lighter in color, inferring that amino acids (components of protein) are more digestible.

Differences in Nutritional Composition, Consistency, Mycotoxins and Feeding Value of DDGS

Differences in nutrient composition and consistency

In general, energy and nutrient content of U.S. DDGS is more consistent than Chinese DDGS. This generally means nutritionists will use less conservative nutrient loading values in feed formulation, which allows them to replace more expensive ingredients to a greater extent to reduce overall diet costs, with less risk of underfeeding energy and nutrients to animals.

To provide an objective comparison of nutrient composition differences, data were summarized from three recently published reports for Chinese DDGS (**Table 1**). In addition, nutrient composition of U.S. corn DDGS sources were summarized from nine published reports (**Table 1**) and Kerr et al. (2013). All data are expressed on a dry matter (dry matter) basis (**Table 1**).

Generally, the crude fat, fiber and protein content contribute to overall metabolizable energy value, and crude protein content is an imprecise indicator of amino acid digestibility. Energy, amino acids and phosphorus are the three most expensive nutrition components in animal feeds. Although DDGS and other commodity ingredients are priced and traded on a moisture, crude protein, crude fat and crude fiber basis, nutritionists use estimates of metabolizable energy (ME), digestible amino acids (especially lysine) and digestible phosphorus to formulate swine and poultry diets. The majority of DDGS fed in China is used in swine and poultry diets. Therefore, the ME, digestible amino acids (especially lysine) and phosphorus content must be compared among these sources to determine if these are substantial feeding value differences.

Average moisture content of Chinese DDGS sources tends to be less than among U.S. DDGS sources, with minimal differences in average crude protein, crude fat and ash content among origins (**Table 1**). However, the range (variation) in crude fat content among Chinese DDGS sources is greater than among U.S. DDGS sources. In addition, the neutral detergent fiber (NDF) content of U.S. DDGS sources is lower and less variable than Chinese DDGS sources. Lower and more variable crude fat content, along with higher and more variable fiber content of Chinese DDGS compared with U.S. DDGS, suggests the metabolizable energy (ME) content of Chinese DDGS would be lower and more variable than U.S. DDGS for pigs and poultry. This is substantiated by comparing swine ME determinations of U.S. corn DDGS (Kerr et al., 2013) with swine ME determinations for Chinese DDGS (Xue et al, 2012; Li et al., 2015). Kerr et al. (2013) reported a narrower range in ME content among 15 sources of U.S. DDGS (3,266 – 3,696 kcal/kg) than Xue et al. (2012; 3,047 – 3,549 kcal/kg) and Li et al. (2015; 2,955-3,899 kcal/kg).

The starch content of Chinese DDGS sources is substantially greater than in U.S. DDGS sources (**Table 1**), inferring incomplete starch fermentation to ethanol, and lower amino acid digestibility. Starch can chemically react with the amino acid lysine during the DDGS drying process to form a chemical bond that renders lysine indigestible. In fact, the average standardized ileal digestibility (SID) of lysine in the Chinese corn DDGS samples (Xue et al., 2012) was lower (52 percent), compared with conventional U.S. DDGS (57 percent) and U.S. high protein DDGS (60 percent). These differences were confirmed by the summarized data from nine published reports (**Table 1**) indicating that the average SID lysine digestibility of U.S. corn DDGS sources is 63 percent.

The phosphorus content of Chinese DDGS is also much lower and more variable (Xue et al., 2012; Li et al., 2015) than found among U.S. DDGS sources (Kerr et al. , 2013). These results imply that for many Chinese DDGS ethanol plants, less of the condensed solubles (high in phosphorus content) is added to the coarse grains before manufacturing DDGS. Phosphorus content is another comparative advantage of U.S. corn DDGS compared with Chinese DDGS in swine and poultry diets.

Table 1. Comparison of published nutrient composition data for corn DDGS produced in China vs. U.S. (dry matter basis)

Measure	Jie et al. (2013) Chinese Corn DDGS	Xue et al. (2012) Chinese Corn DDGS	Li et al. (2015) Chinese Corn DDGS	U.S. Corn DDGS Summary[1]	Kerr et al. (2013) U.S. Corn DDGS
Moisture %	6.49 - 12.1 (8.5)	10.7 - 10.9 (10.9)	9.6 - 13.5 (11.4)	6.6 – 14.7 (11.2)	10.0 – 15.2 (12.4)
Crude protein %	25.4 - 32.3 (29.6)	26.4 – 32.0 (28.8)	28.5 - 36.8 (32.2)	27.2 - 40.8 (30.8)	27.7 – 32.7 (30.5)
Crude fat %	1.5 - 16.2 (9.3)	9.2 – 12.6 (10.5)	2.8 - 13.6 (8.6)	4.6 – 14.1 (10.6)	4.9 – 13.2 (9.7)
NDF %	45.0 - 65.8 (54.3)	43.4 – 49.5 (46.4)	31.0 - 46.6 (37.1)	30.2 – 49.6 (38.6)	28.8 – 44.0 (35.4)
Ash %	2.1 - 8.4 (5.5)	ND[2]	2.9 - 9.1 (5.4)	1.78 – 6.6 (4.4)	4.3 – 6.1 (5.1)
Starch %	ND	ND	5.3 – 16.3 (11.6)	ND	0.84 – 3.89 (2.2)
P %	ND	0.25 – 0.55 (0.39)	0.33 - 1.01 (0.75)	ND	0.71 – 0.91 (0.84)
Lysine %	ND	0.46 – 0.67 (0.56)	0.74 – 1.08 (0.91)	0.55 – 1.36 (0.94)	ND
SID[3] Lysine %	ND	0.19 – 0.29 (0.25)	ND	0.22 – 0.92 (0.59)	ND

[1]Data obtained from Fastinger and Mahan (2006); Stein et al. (2006); Pahm et al. (2008); Stein et al. (2009); Urriola et al. (2009); Jacela et al. (2010); Almeida et al. (2011); Kim et al. (2012) and Soares et al. (2012)

[2]ND = no data provided

[3] SID = standardized ileal digestible

Lysine is the first limiting amino acid in swine and poultry diets, which means it is the most likely of all amino acids to be deficient in corn and soybean meal-based diets. Therefore, lysine content and digestibility are key indicators of the nutritional value of various sources of DDGS. Furthermore, lysine content and digestibility is highly variable among Chinese and U.S. DDGS sources. Based on the limited data available for comparing lysine digestibility among Chinese and U.S. DDGS sources, it appears a greater proportion of U.S. DDGS sources have greater lysine digestibility than Chinese DDGS sources (Xue et al., 2012).

Differences in mycotoxin content in DDGS

Studies have shown that mycotoxins in feed ingredients are an ongoing concern and major problem in the Chinese feed and livestock industry. Very few Chinese grain farmers have access to grain drying equipment and proper grain storage, which leads to high prevalence and concentrations of mycotoxins that can have significant adverse health and performance effects when contaminated feed ingredients are fed to livestock and poultry. While corn and other grains produced in the U.S. and other parts of the world may contain mycotoxins, depending on climatic growing, harvest and storage conditions, the prevalence of contamination and concentrations of mycotoxins are significantly less than for grains and DDGS produced in China.

One of the major limiting factors of diet inclusion rates of DDGS is mycotoxin content. Nutritionists strive to minimize total mycotoxin content because mycotoxins cause reduced animal performance and poor health. The prevalence of mycotoxin contamination and concentrations in U.S. DDGS is much lower than Chinese DDGS. Biomin (2014) conducted a survey to collect and analyze 4,218 feed ingredient samples from over 50 countries for mycotoxins. Feed ingredients collected from Asia had the highest concentrations for most mycotoxins determined, and 65 percent of all samples contained more than one mycotoxin, compared with samples from North America, South America, Middle East and Africa. Li et al. (2014) evaluated 55 feed ingredients (including 17 DDGS samples) and 76 complete swine feeds produced in the Beijing region of China. Their results showed DDGS had the most serious mycotoxin contamination of all ingredients with 6 percent, 88 percent and 41 percent of samples exceeding Chinese regulatory limits for aflatoxin B1 (50 ppb), deoxynyvalenol (1,000 ppb) and zearalenone, respectively. In another study (Guan et al., 2011), 83 complete feed and feed ingredient samples were collected from various regions of China, which included five Chinese DDGS samples. Results from this study showed that 100 percent of the samples had positive concentrations of mycotoxins and the average concentrations of the six mycotoxins were greater than the overall average of all ingredients.

Two extensive surveys of mycotoxin contamination in U.S. DDGS have been published in recent years (Zhang et al., 2009; Khatibi et al., 2014). Zhang et al. (2009) collected 235 DDGS samples from 20 ethanol plants in the U.S. and 23 export shipping containers from 2006 to 2008. Results from this study showed:

1. None of the DDGS samples contained aflatoxins or deoxynivalenol concentrations above the U.S. FDA guidelines for use in animal feed.

2. None of the DDGS samples contained concentrations of fumonisins greater than FDA guidelines for use in dairy, beef, swine, poultry, and aquaculture feeds, and only ten percent of the samples contained concentrations of fumonisins greater than maximum levels for use in equine (horse) and rabbit (most sensitive species to fumonisins) feeds.

3. None of the samples contained detectable concentrations of T-2 toxins, and most samples contained undetectable concentrations of zearalenone.

4. Containers used for exporting DDGS did not contribute to mycotoxin production.

Another DDGS mycotoxin survey conducted by Khatibi et al. (2014) involved analyzing 141 corn DDGS samples from 78 ethanol plants located in 12 states in the U.S., for the tricothecenes deoxynivalenol (DON), 15-acetyldeoxynivalenol (15-ADON), 3-acetyldeoxynivaleniol (3-ADON), nivalenol (NIV) and zearalenone (ZON). In 2011, there was an unusually high prevalence of Fusarium spp. in the U.S. corn crop, which can infrequently occur during years with adverse weather conditions during the corn growing season. No other study has been published that has evaluated 15-ADON, 3-ADON and NIV in DDGS. Sixty-nine percent of the samples contained no detectable levels of DON, and the samples with detectable levels contained one to five ppb DON. Only 5 percent of the samples were above the FDA advisory levels for swine. Eighty-five percent of samples had no detectable concentrations of 15-ADON, and none of the samples contained detectable levels of 3-ADOn or NIV. Only 19 percent of the samples contained detectable concentrations of ZON.

Results from these studies indicate there is much lower risk and concentrations of mycotoxins in U.S. DDGS than found in Chinese DDGS samples (Guan et al, 2011; Li et al., 2014). As a result, U.S. DDGS can be used at higher diet inclusion rates than Chinese DDGS while minimizing the risk of exceeding total diet mycotoxin concentrations above recommended levels.

Differences in feeding value and use of DDGS in animal feeds

The majority of DDGS used in China is consumed in the swine and poultry industries. U.S. DDGS has several advantages over Chinese DDGS, particularly for swine, poultry and dairy cattle. Because Chinese DDGS has greater prevalence and concentrations of mycotoxins than U.S. DDGS, the risk of reduced animal performance and health, as well as mycotoxin contamination in cow's milk), is significantly reduced by feeding U.S. DDGS. Furthermore, U.S. DDGS is generally less variable in energy and nutrient content (corn is the primary feedstock used and production processes are generally similar among ethanol plants), and has higher lysine digestibility and phosphorus content, making it more valuable in feed formulations than Chinese DDGS.

Jewison and Gale (2012) summarized estimates of diet inclusion rates for various animal species (**Table 2**). Jewison and Gale (2012) also estimated total DDGS consumption by species in China to be 10 percent for dairy cattle, 20 percent for swine, 60 percent for poultry and 10 percent for aquaculture.

Potential feed safety risks of Chinese DDGS

Due to melamine contamination of infant formulas and other food safety scandals that have occurred in China products in recent years, there is widespread global concern and skepticism about feed and food safety of Chinese products. Gale and Buzby (2009) indicated that food safety risks are difficult to manage in Chinese food products because of weak enforcement of food safety standards by the Chinese government, heavy use of agricultural chemicals and extensive environmental pollution. As a result, technology has been developed to distinguish country of origin of DDGS and other feed products (Tena et al., 2015). Use of NIR analysis enabled excellent results in discriminating DDGS samples from China vs. pooled samples from Europe and the U.S. (Tena et al., 2015). This suggests there are distinct composition and quality differences among DDGS samples produced in China compared with those produced in Europe and the U.S.

Table 2. Comparison of the percentage of diet inclusion rates for dairy, beef, swine, and poultry in China and the U.S. (Jewison and Gale, 2012)

Species	China	United States
Dairy cattle	20 to 30 percent	10 to 20 percent
Beef cattle	No Data Available	10 to 40 percent
Swine	10 to 12 percent	10 to 50 percent
Poultry	5 to 10 percent	5 to 10 percent

Global Market Demand for U.S. DDGS

Exports of U.S. DDGS have been increasing since 2007 as U.S. ethanol and DDGS production have also increased, where more than 31 different counties have imported U.S. DDGS. The major export markets for U.S. DDGS are Mexico, various countries in Asia, Canada and Turkey. This growth in global demand indicates U.S. DDGS is an economically competitive feed ingredient in many countries on five continents, and is attractive because of its high quality and excellent nutritional value compared to other alternative feed ingredients.

Because DDGS is a high energy, moderate protein feed ingredient, it tends to follow corn price more closely than soybean meal price. U.S. DDGS prices are based on the global market, with minimum guarantees of crude protein and crude fat content. Historically, U.S. DDGS has been priced based on a composite of protein and fat content "profat" minimum guarantees. However, partial extraction of corn oil prior to manufacturing DDGS has complicated the use of this composite measure to establish price because protein content does not increase to the same extent as the decline in crude fat content in reduced-oil DDGS. Therefore, many buyers and sellers are establishing price based on separate minimum guarantees for crude protein and crude fat.

Chinese tariff and tax policies are important factors that affect imports of DDGS compared with other feed ingredients (Jewison and Gale, 2012). As of 2012, DDGS was not subjected to import quotas, exempt from value-added taxes (VAT), and were assessed a relatively low (five percent) tariff. In contrast, imports of corn are regulated by a tariff rate quota system, and subjected to a one percent tariff and 13 percent VAT.

Chinese feed ingredient buyers are very price sensitive. The large amounts of U.S. DDGS purchased by Chinese buyers in recent years can sometimes be attributed to a lower price compared with Chinese corn, but better quality, consistency, and nutritional value of U.S. DDGS compared with Chinese DDGS appear to be very important factors. As an example, Jewison and Gale (2012) indicated that from June to December, 2011, the average price of U.S. DDGS imported to China was 19 percent lower than the cost of domestic Chinese corn and 35 percent lower than soybean meal. However, during this time period, the price of domestic Chinese DDGS (northeast China) was 13 percent lower than the price of imported U.S. DDGS.

However, Chinese DDGS buyers are willing to pay a premium price for imported U.S. DDGS because of its improved quality and consistency compared with Chinese DDGS (Jewison and Gale, 2012). Chinese buyers prefer the lighter, and more golden color of U.S. DDGS compared with Chinese DDGS because it has greater feeding value, and they have fewer problems with customer acceptance of the color of finished complete feed products.

Due to high demand for raw materials for animal feed production, very little, if any DDGS produced in China is exported. Corn production and supply is most abundant in northeast China, which is also where the majority of domestic DDGS is produced (Jewison and Gale, 2012). However, a high proportion of swine and poultry production and feed manufacturing occurs in the southern region of China, causing high transportation costs to move these ingredients to this region where they are consumed. As a result, corn prices in southern China (e.g. Guangdong) are 12 to 15 percent greater than in northeast China (Jewison and Gale, 2012). Therefore, southern China is the main geographical location that uses imported U.S. DDGS.

As a result, imported U.S. DDGS tends to be used in areas in close proximity to the ports due to transportation costs to move to the interior of China. For this reason, Chinese DDGS production is used to a greater extent in regions near the ethanol plants.

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