Feeding DDGS to pigs: What is new?

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ABSTRACT: The usage of distillers dried grains with solubles (DDGS) in the swine industry is rapidly increasing and it is expected that the usage will further increase in the future. However, the quality of DDGS may vary and in particular, the concentration of digestible lysine in DDGS has been shown to vary, which is a concern because lysine is usually limiting in diets containing DDGS. Some DDGS products have been heated to an extent that the concentration and the digestibility of lysine has been reduced and it is, therefore, important that the concentration of lysine is measured in DDGS before it is used. If the furosine concentration is also measured, the concentration of reactive lysine can be calculated. If DDGS is included in diets fed to pigs, pig performance may be maintained if the inclusion is limited to 20% although even at this inclusion level, pig performance has sometimes been reported to be reduced. On the other hand, greater inclusion levels have also been used on some occasions without reducing pig performance. It is not know at this point why these different responses to DDGS are obtained but it may be related to the quality of DDGS used or to the way diets containing DDGS were formulated. In most instances, however, the iodine value of the belly fat of pigs fed DDGS will increase, but the mechanisms behind this observation are not fully

understood. Many new fractionated products from the ethanol industry will become available in the future. Most of these products will have lower concentrations of fiber and fat but greater concentrations of protein compared with conventional DDGS. The feeding value of a few of these new products has been measuredc, but as more products enter the market, more research to describe the value of these products is needed.

Fractionated co-products

The traditional co-product from the ethanol industry is distillers dried grains with solubles (**DDGS**). This product consists of the entire corn kernel except the starch that was removed during fermentation in the ethanol plant. Most ethanol plants are constructed to only remove the starch and DDGS is, therefore, by far the most dominant co-product from the industry. However, several plants are now either fractionating the corn kernel prior to fermentation or fractionating the DDGS produced after fermentation and it is expected that more ethanol plants will start fractionation in the future. This will result in many new co-products becoming available to the feed industry.

Fractionation of the corn kernel prior to fermentation consists of removal of the hulls and the germ from the kernel. The hulls are marketed to ruminant animals because of their relatively high concentration of fiber, but the corn germ is marketed to monogastric animals. This product, which is different from corn germ meal produced from wet milling, contains approximately 18% fat and 1.10% P. The concentration of DE and ME in corn germ and the digestibility of P are similar to corn, but the digestibility of AA is similar to DDGS (Widmer et al., 2007a). The feeding value of corn germ in diets fed to pigs is relatively high and there is evidence that the inclusion of corn germ in diets fed to finishing pigs results in improved belly firmness and reduced iodine values (Widmer et al., 2007b).

When the degermed and dehulled corn has been fermented in the ethanol plant, a high-protein, low fat and low fiber co-product is produced. The solubles produced during this process are usually added to the corn hulls and not to the distilled grain. Therefore, a distillers dried grains (**DDG**) product rather than a DDGS product is produced and because of the relatively high protein concentration in this product (approximately 40% CP) it is called high protein DDG (**HP DDG**). The digestibility of AA and P in HP DDG is similar to conventional DDGS, but because of the lower fiber concentration, the DE and ME in HP DDG is greater than in conventional DDGS (Widmer et al., 2007a). The inclusion of 20% HP DDG in diets fed to pigs is recommended, but if 40% is used, feed intake may be reduced during the growing period (Widmer et al., 2007b).

Other fractionation technologies use down-stream fractionation. The most simple form of down-stream fractionation consists of removal of some of the oil in the distilled grain. This oil can then be marketed to higher priced markets or used in the bio-diesel industry. The resulting DDGS contains 4 to 6% crude fat rather than 9 to 10% fat. No experiments have been conducted to measure the nutritive value of this product, but it is expected that the energy value is reduced by at least 10 to 15% compared with conventional DDGS. The low-fat DDGS product is, therefore, less valuable if fed to monogastric animals compared with conventional DDGS.

Other down-stream technologies consist of removal of some of the fibers from DDGS after fermentation. At this point, there are no data available on the feeding value of these products to pigs, but some of these products are marketed to the aquaculture and pet food markets. It is expected that new fractionation technologies will be introduced in the future and that new co-products will become available to the feed industry.

Estimation of heat damage in DDGS

The digestibility of Lysine in DDGS is more variable than the digestibility of most other AA (Fastinger and Mahan, 2006; Stein et al, 2006). The reason for this observation is most likely that drying of DDGS induces heat damage because of Mailard reactions that result in a reduced concentration of lysine as well as a reduced digestibility of lysine. It has been shown that the DDGS samples that have the lowest concentration of lysine usually also have the lowest digestibility, which is consistent with this hypothesis (Stein, 2007). It has also been shown that 60% of the variability in lysine digestibility in DDGS can be explained simply by the lysine concentration and it is, therefore, recommended that the lysine concentration be measured in DDGS to estimate the concentration of digestible lysine. If the CP concentration is also measured, the lysine concentration as a ratio of CP can be calculated. Because the Mailard reaction reduces lysine concentration in the sample, but not the CP concentration, this ratio will be reduced if samples are heat damaged. The average lysine:CP ratio in DDGS is 2.86%, but samples with a ratio as low as 2.20% have been measured (Stein, 2007). It is recommended that only samples with a ratio greater than 2.80% is used in diets fed to swine.

Other procedures to estimate heat damage of lysine in DDGS includes measuring the concentration of reactive lysine using a homoarginine or a furosine procedure. Both of these procedures have been shown to estimate lysine digestibility with an accuracy of approximately 70%. However, the homoarginine procedure is relatively tedious and slow to perform and may not be practical as a routine measure of lysine damage. In contrast, furosine can be measured relatively easy using HPLC analysis and may be used as a routine measurement by DDGS producers and feed mills.

The Mailard reaction in its later stages introduces browning reactions and theoretically, a measure of color may be used to estimate the degree of heat damage in DDGS. However, color measurements are influenced by particle size and it has been shown that color measurements of DDGS samples obtained from a large number of ethanol plants cannot be used to accurately predict the digestibility of lysine. However, it is possible that color measurements of DDGS samples obtained over time from the same ethanol plant can be used as a predictor of lysine digestibility, but this hypothesis has not yet been experimentally verified.

Feeding value of DDG vs. DDGS

During production of DDGS, the solubles and the distillers grain are mixed together. Newer data indicate that the heat damage to lysine is mainly a result of the addition of solubles to distillers grain (Pahm et al., 2007). As a consequence, if the addition of solubles to distillers grain is avoided, which would result in the production of DDG rather than DDGS, then it is expected that the risk of heat damage is greatly reduced. Unfortunately, no research has been conducted to specifically test this hypothesis. However, it has been shown that the digestibility of lysine in one source of DDG is greater than in DDGS (Pahm et al., unpublished). This observation is consistent with the hypothesis that the addition of solubles to the distillers grain increases the risk of heat damage in the product. The practical consequence of this observation is that the risk of reduced lysine concentration and reduced lysine digestibility is lower in DDG than in DDGS.

DDGS from the beverage industry vs. DDGS from the ethanol industry

The majority of DDGS that is available to the feed industry is a co-product from the ethanol industry but a significant amount of DDGS is also produced by the beverage industry. Only limited research has been conducted to compare the quality and the feeding value of these two sources of DDGS. However, based on the available data it is concluded that the quality of DDGS cannot be predicted on the basis of where it comes from and it was recently shown that the digestibility of AA in beverage DDGS is not different from the digestibility in ethanol DDGS (Pahm et al, unpublished). Within both ethanol DDGS and beverage DDGS, the quality can be poor or great dependent on the way the product was produced and the temperature used during drying.

Concentration and digestibility of phosphorus in DDGS

The concentration of phosphorus in DDGS has been reported to be between 0.72 and 0.78% (NRC, 1998; Spiehs et al., 2002). However, the average P concentration in 45 sources of DDGS was recently reported at only 0.61% (Stein, 2007). The reason for this much lower value is unknown, but recent measurements in the feed industry have verified this lower value.

It has also been reported that the apparent total tract digestibility (**ATTD**) of P is approximately 59% in DDGS as well as in HP DDG (Pedersen et al., 2007; Widmer et al., 2007). This value is much lower than the 77 to 85% relative availability of P that has been previously reported (NRC, 1998; Fent et al., 2004). However, values for relative availability are not digestibility values and cannot be directly compared with values for ATTD. To compare these values, it is necessary to know the digestibility of the P-source that is used as a standard for the assessment of the relative availability. As an example, if the 77% relative availability of P that is reported by NRC was obtained by comparing the availability of P in DDGS to the availability of P in dicalcium phosphate and if the ATTD of P in dicalcium phosphate is 80% (Petersen and Stein, 2006), then the calculated ATTD of P in DDGS would be 77% of 80, which is 62%. This value is in good agreement with the ATTD of 59% reported by Pedersen et al. (2007). Bottom line is that it is important to distinguish between values for ATTD and values for relative availability of P. In practical feed formulation, values for ATTD should be used.

Formulation of diets containing DDGS

Several experiments have been conducted recently using DDGS in diets fed to sows, weanling, growing, and finishing pigs. In some of these experiments, it was reported that DDGS can be included at concentrations of 20 or 30% without affecting pig or sow performance (Cook et al., 2005; DeDecker et al., 2005; Song et al., 2007; Spencer et al., 2007; Widmer et al., 2007b). However, in other experiments, reduced pig performance was reported if DDGS was included in the diets (Linneen et al., 2006; Whitney et al., 2006; Hinson et al., 2007). It is not known why these different responses are obtained, but it is possible that differences in the quality of DDGS used in the experiments may explain these differences because poor pig performance would be expected if DDGS with a low concentration of digestible lysine is used. It is also possible that the poor pig performance reported from some experiments is a result of the way diets containing DDGS were formulated because the inclusion of DDGS in the diets was accompanied by an increase in the CP concentration of the diets. The reason for this increase is that the protein in DDGS contains a relatively low concentration of lysine and tryptophan. This problem can be easily overcome in diet formulations by increasing the inclusion of crystalline sources of these AA in diets containing DDGS. However, if the inclusion of crystalline AA is not increased, then the concentration of CP in the DDGS containing diets will increase. This can result in reduced feed intake, reduced dressing percentage, and reduced intestinal health, which in turn will reduce pig performance. In all the experiments, in which reduced pig performance has been reported as a result of inclusion of DDGS, diets were formulated without inclusion of increased levels of crystalline AA and the DDGS containing diets had, therefore, greater concentrations of CP than the control diet. As a consequence, the effects of increased concentrations of DDGS cannot be distinguished from the effects of increased concentrations of CP and it is not possible to determine if the reduced performance reported for pigs fed these diets is a result of the increase in DDGS or the increase in CP. However, in experiments where diets were formulated in such a way that the concentration of CP did not increase as DDGS was included in the diets, no difference in pig performance was observed (Song et al., 2007; Widmer et al., 2007b). It is, therefore, important that research be conducted to investigate the independent effects of DDGS and of dietary CP, but until results of such research has been completed, it is recommended that diets containing DDGS be formulated without increasing the concentration of CP.

Effects of DDGS on product quality

The inclusion of DDGS in diets fed to finishing pigs does not influence the palatability of bacon or pork chops and a person would not be able to distinguish between products originating from pigs fed corn-soybean meal diets and pigs fed corn-soybean meal-DDGS diets (Widmer et al., 2007b). However, the inclusion of DDGS in diets fed to finishing pigs will result in pigs developing softer bellies with increased iodine values compared with pigs fed corn soybean meal control diets (Whitney et al., 2006; Widmer et al., 2007b). This increase in the iodine value of the belly is greater if pigs are fed diets containing DDGS than if they are fed a diet containing a similar amount of pure corn oil and it appears that the iodine values in bellies of pigs fed DDGS cannot be fully explained by the iodine value of the diet. The reason for this observation is unknown but research to elucidate this effect is needed to better understand the effects of DDGS on belly firmness.

Conclusions

The amount of DDGS that is available to the feed industry will continue to increase and it is important that strategies for including DDGS in diets fed to pigs continue to be refined. Based on the current body of research, it is concluded that lactating, weanling, growing, and finishing pigs can be fed diets containing up to 20% DDGS provided that a good quality of DDGS is used. Diets fed to gestating sows may contain 40% DDGS. However, in many experiments greater inclusions of DDGS has been reported not to compromise pig performance, but in other experiments, pig performance has been reduced even at modest inclusions of DDGS. There is, therefore, a need for more research to investigate the reasons for these different responses to inclusion of DDGS in diets fed to pigs. It is also important that the reasons for the increase in belly iodine values that has been reported for pigs fed DDGS are investigated to make sure that product quality is not compromised. If DDGS is used, it is important that the diets are formulated in such a way that the concentration of CP is not increased. All diets should be formulated on the basis of digestible AA and digestible P and DDGS should be used only if the lysine to CP concentration is greater than 2.80. It is, therefore, important that the lysine and CP concentrations be measured in DDGS before it is included in diets fed to swine.

In the future, many new co-products from the ethanol industry will become available to the feed industry. However, each of these new products needs to be characterized in terms of concentration and digestibility of energy and nutrients before they can be included in diets fed to pigs.

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