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Does Feeding Diets Containing DDGS Affect Pork Quality?

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One of the hottest topics related to DDGS use in the pork industry today involves questions related to whether feeding diets containing DDGS will have a negative effect on pork quality and, specifically, pork fat quality. Most of the DDGS used in swine feed is consumed in the grower-finisher phase of production at a dietary inclusion rate of 10%. However, many nutritionists and pork producers want to use higher levels of DDGS to achieve greater diet cost savings without compromising growth performance and carcass quality. Very little research has been conducted to evaluate the effects of increasing dietary levels of DDGS on growth performance and carcass quality of grow-finish pigs. We have completed two studies at the University of Minnesota to get an initial look at this question. We also have two additional studies underway that will give us a more complete understanding of how different dietary levels of DDGS and the length of feeding period affects pork quality. However, until these studies are completed, here is what we know so far:

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Corn DDGS contains about 10% corn oil. The high oil content of DDGS is important because it allows DDGS to retain about the same amount of energy as corn. As a result, the energy value of swine diets is maintained when DDGS is added to replace some of the corn. Fat or oil contains high amounts of energy, and supplemental fat is commonly added to commercial corn/soybean meal swine diets to improve growth rate and feed conversion of grower-finisher pigs (Pettigrew and Moser, 1991; Engel et al., 2001). However, when feeding diets containing supplemental fat are fed to swine, there is the potential to change the proportion of unsaturated fatty acids in the fat depots of the pigs, and increase the likelihood of soft fat problems, depending on the type and level of fat added to the diet.

Soft pork fat is an undesirable property that affects further processing of pork products, may cause pork products to not meet product specifications and can lead to a lower price or value (Irie et al., 1992). Problems that occur from soft pork fat include bacon sticking together, an oily appearance in the package, reduced product shelf life, and increased susceptibility to oxidative damage (NPPC, 2001; Carr et al., 2005). Soft fat is also a concern in sausage manufacturing because it creates an unattractive appearance, and the soft and highly unsaturated fat is easy to melt, which results in the formation of a fat coating on the product (Carr et al., 2005).

Corn oil contains a relatively high amount of unsaturated fatty acids (86.7%) and linoleic acid (59%), and a low level of saturated fatty acids (13.3%), resulting in a high unsaturated:saturated fatty acid ratio of 6.53 (NRC, 1998). We have known for many years that pork fat composition is very similar to the fat composition in the pig's diet. You could say that "pigs are what they eat." In a study conducted in 1926, Ellis and Isbell demonstrated that feeding swine diets containing a high ratio of unsaturated:saturated fatty acids resulted in soft body fat, and that the fatty acid profile in pork fat can be altered to an undetermined extent by varying the linoleic acid level of diet. This response has been confirmed in several subsequent research studies (Leat et al., 1964; Dahl and Persson, 1965; Brooks 1971; Wiseman and Agunbiade,1998; Warnants et al., 1999; Eggert et al., 2001; Carr et al., 2005).

The effects of dietary fat source on pork fat quality can also vary due to gender. Several studies have shown that the magnitude of fatty acid change in adipose tissue due to dietary fat source is greater in gilts than in barrows because gilts typically have less fat, more "carcass lean," and more

Table 1				
Effect of Dietary DDGS Level on Overall Growth Performance of Grower-Finisher Pigs				
	0% DDGS	10% DDGS	20% DDGS	30% DDGS
ADG, lbs.	1.90[a]	1.89[a]	1.82[bc]	1.78[bd]
ADFI, lbs.	5.24	5.22	5.09	5.19
Feed/Gain	2.76[a]	2.76[a]	2.80[a]	2.92[b]
Final Wt., lbs.	258[a]	259[a]	252[b]	247[b]

[a, b] Means within row with unlike superscripts are different (P < .05).
[c, d] Means within row with unlike superscripts are different (P < .10).

unsaturated fatty acids in adipose tissue than barrows (Leszczynski et al.,1992; Warnants et al., 1996; 1999; Gatlin et al., 2003).

In order to prevent soft pork fat, a fairly rigid standard was established by the Danish Meat Research Institute (Barton-Gade, 1987). Using iodine value (ratio of unsaturated:saturated fatty acids) as the criteria for measurement of pork fat quality, a maximum iodine value of 70 is used as the standard for comparison in Europe. In addition, European dietary specifications generally include a maximum dietary level of linoleic acid, which is commonly set at about 1.6% in diets for finisher pigs. However, this threshold value has not been clearly established for pork produced in the United States (Ellis et al., 1998). Boyd (1997) suggested that the iodine value threshold for pork fat in the United States should be set at 74, and dietary linoleic acid levels should be set at a maximum of 2.1 % of the diet because pigs fed a corn-soybean meal diet with no added fat could exceed an iodine value of 70. Soft fat is an undesirable property for further processing and the ability of pork products to meet export specifications, especially in Japan. Japan is the largest export market for U.S. pork, and soft fat is the principle factor for downgrading and reducing the price because of decreased quality of processed pork products (Irie et al., 1992).

Study No. 1

In our first study (Whitney et al., 2006), a total of 240 crossbred pigs with an initial body weight of about 63 pounds were assigned to one of four diet sequences in a five-phase grower-finisher feeding program. Corn/soybean meal diets were formulated to contain 0%, 10%, 20% or 30% DDGS. Diets were formulated on total lysine basis and also contained up to 4% soybean oil as a supplemental fat source. Soybean oil was chosen as the supplemental fat source for this study because we did not have the ability to use animal fats at the location where this study was conducted. Therefore, these experimental diets contained unusually high levels of unsaturated fatty acids compared to what is currently being fed to grower-finisher pigs in the U.S. pork industry.

As shown in Table 1, pigs fed the diets containing 10% DDGS grew at the same rate, consumed the same amount of feed and had the same feed conversion as pigs fed the control corn/soybean meal diets. Feeding diets containing 20% DDGS resulted in a reduced growth rate, but feed conversion was not significantly affected. However, feeding the diets containing 30% DDGS reduced growth rate and feed conversion compared to pigs fed the corn/soybean meal control diets or the diets containing 10% DDGS. This reduction in performance at higher DDGS inclusion rates was likely due to formulating diets on a total amino acid basis and not accounting for the digestibility of amino acids in DDGS, which likely resulted in not meeting the pigs' amino acid requirements at the 20% and 30% dietary inclusion rates for DDGS.

At the end of the feeding portion of this study, pigs were slaughtered to obtain carcass (Table 2), muscle (Table 3) and fat (Table 4) quality measurements. Carcass weight and dressing percentage of pigs fed the 0% and 10% DDGS diets were the same, and greater than those from pigs fed the 20% and 30% DDGS diets. The lighter carcass weights of pigs fed the 20% and 30% DDGS diets were a result of reduced growth rate and lighter live weights compared to pigs fed the 0% and 10% DDGS diets. However, there was no difference in back fat thickness or percentage of carcass lean among the different DDGS feeding levels. Pigs fed the 0% DDGS diets had greater loin depths compared to pigs fed the 30% DDGS diets, with intermediate loin depths from pigs fed either 10% or 20% DDGS. The differences in loin depth were influenced by the differences in slaughter weight of pigs among the four dietary treatments. These results indicate that, although growth performance was negatively affected by feeding diets containing 20% or 30% DDGS, carcass composition was largely unaffected as indicated by the similar fat depths and percent carcass lean across dietary treatments.

Furthermore, none of the muscle quality measurements—except "11-day purge loss"—were affected by dietary DDGS level (Table 3). It is unclear why muscle from pigs fed the 20% DDGS had a higher 11-day purge loss compared to muscle from pigs fed the control diet, but 11-day purge loss was not different between the 0%, 10% and 30% DDGS treatments. These data indicate adding DDGS at levels up to 30% in swine finishing diets did not have meaningful effects on pork muscle quality.

Iodine number increased linearly, and thus, belly fat became more unsaturated as the dietary concentration of DDGS increased (Table 4). Researchers have clearly established that feeding diets containing an unsaturated fat source can alter the degree of saturation in pork fat. Lea et al. (1970) indicated that adequately firm pork fat has an iodine number below 70. Boyd (1997) suggested the iodine value threshold for pork fat in the United States should be set at 74. In our study, iodine values were greater than 70 but less than 74 for the diets containing 30% DDGS, and about 70 for the pigs fed the 20% DDGS diets. A significant amount of unsaturated fatty

Table 2

Effects of Dietary DDGS Level on Carcass Characterisitics of Grower-Finisher Pigs

	0% DDGS	10% DDGS	20% DDGS	30% DDGS
Slaughter weight, lbs.	258	263	249	247
Carcass weight, lbs.	189[c]	191[c]	180[d]	178[d]
Dressing %	73.4[c]	72.8[c]	72.1[d]	71.9[d]
Fat depth, in.	0.85	0.87	0.84	0.82
Loin depth, in.	2.26[ac]	2.16[b]	2.19[c]	2.06[d]
% Carcass lean	52.6	52.0	52.6	52.5

[a, b] Means within row with unlike superscripts are different ($P < .05$).
[c, d] Means within row with unlike superscripts are different ($P < .10$).

Table 3

Muscle Quality Characteristics from Grower-Finisher Pigs Fed Diets Containing 0%, 10%, 20% and 30% DDGS

	0% DDGS	10% DDGS	20% DDGS	30% DDGS
L*c	54.3	55.1	55.8	55.5
Color scored	3.2	3.2	3.1	3.1
Firmness score[e]	2.2	2.0	2.1	2.1
Marbling scoref	1.9	1.9	1.7	1.9
Ultimate pH	5.6	5.6	5.6	5.6
11-d purge loss, %	2.1[a]	2.4	2.8[b]	2.5
24-hour drip loss, %	0.7	0.7	0.7	0.7
Cooking loss, %	18.7	18.5	18.3	18.8
Total moisture loss, %[g]	21.4	21.5	21.8	22.1
Warner-Bratzler sheer force, kgh	3.4	3.4	3.3	3.3

[a, b] Means within row with unlike superscripts are different ($P < .05$).
[c] 0 = black, 100 = white
[d] 1 = pale pinkish gray/white; 2 = grayish pink; 3 = reddish pink; 4 = dark reddish pink; 5 = purplish red; 6 = dark purplish red
[e] 1 = soft, 2 = firm, 3 = very firm
[f] Visual scale approximates % intramuscular fat content (NPPC, 1999)
[g] Total moisture loss = 11-day purge loss + 24-hour drip loss + cooking loss
[h] Measure of tenderness

Table 4

Fat Quality Characteristics of Market Hogs Fed Corn-Soybean Meal Diets Containing 0%, 10%, 20% and 30% DDGS

	0% DDGS	10% DDGS	20% DDGS	30% DDGS
Belly thickness, cm	3.15[a]	3.00[ab]	2.84[bc]	2.71[c]
Belly firmness score, degrees	27.3[a]	24.4[a]	25.1[a]	21.3[b]
Adjusted belly firmness score, degrees	25.9[d]	23.8[de]	25.4[d]	22.4[e]
Iodine number	66.8[d]	68.6[e]	70.6[f]	72.0[f]

[a, b, c] Means within row with unlike superscripts are different ($P < .10$).
[d, e, f] Means within row with unlike superscripts are different ($P < .05$).

acids was supplied to experimental diets from supplemental soybean oil in addition to the corn oil present in DDGS in this study. We estimate, based on NRC (1998), that a typical swine finishing diet without supplemental fat (85% corn, 11% soybean meal) would contain about 3% unsaturated fatty acids. By comparison, we estimated our phase-five control diet contained 4.33% unsaturated fatty acids and the phase-five diet with 30% DDGS contained 4.96% unsaturated fatty acids. We expect that if an animal fat source, which is lower in unsaturated fatty acid concentration, were added to these diets, or if no supplemental fat was added, the iodine values of carcass fat from pigs fed high concentrations of DDGS would be lower. At the same time, the negative effects of adding high levels of DDGS to the diets on pork fat quality would be less. The effect of DDGS feeding on iodine number was reflected in the analysis of belly firmness score. Lower belly firmness scores indicated that bellies from pigs that were fed 30% DDGS were softer than bellies from pigs fed 0.0% or 20% DDGS. Softer bellies were most likely a consequence of elevated concentrations of dietary unsaturated lipids supplied by soybean oil and DDGS.

Based upon these results, including 10% distiller's dried grain with solubles in conventional swine grower-finisher diets has no detrimental effects on pig performance, carcass quality or pork quality. When diets are formulated on a total amino acid basis, it appears that inclusion rates of 20% or higher result in depressed growth performance. Including distiller's dried grain with solubles at concentrations of 20% to 30% of the diet—and using soybean oil as a supplemental fat source for grower-finisher pigs—does not affect muscle composition or quality, but decreases the saturation of fatty acids, resulting in softer bellies, and may negatively affect further processing traits.

Study No. 2

We recently completed a second study to further evaluate the impact of feeding conventional corn/soybean meal grower-finisher diets, with or without 10% DDGS, on pork fat quality. This study was funded by Land O' Lakes Purina Feed and was a field study to validate that feeding diets containing 10% DDGS under commercial field conditions have no detrimental effect on pork fat quality.

Two cooperating pork producers were selected for this study. Each producer had typical commercial, 1,000-head finishing barns and was located in southern Minnesota. Each barn had 40 pens, was a double-curtain-sided building with 8-foot pits, utilized pit fans for ventilation and had weighted baffle ceiling air inlets. Both farms had common genetics consisting of Monsanto Genepacker sows mated with Monsanto EB terminal line boar semen. The overall health status of both groups of pigs was very good. Feed for both farms was formulated and provided by Land O' Lakes/Purina Feed. Producer A fed typical corn-soybean meal diets, whereas Producer B fed corn-soybean meal diets containing 10% DDGS. A seven-phase, mixed-sex feeding program was used, and the last finisher diet contained 4.5 grams of Paylean. Diets within each phase contained similar nutrient levels with and without 10% DDGS. All diets within each phase contained the same level of choice white grease as the supplemental fat source (supplemental levels ranged from 1.25% to 3.75% depending on the diet phase).

One hundred twenty-eight pigs were randomly selected from each group for evaluation of carcass traits. At 24 hours postmortem, a total of 48 mid-belly samples were collected from each dietary treatment group with equal numbers of barrows (12) and gilts (12) from each farm. From the 48 mid-belly samples, a visual color score (on a scale from 1 to 4—with 1 equaling "pale" and 4 equaling "dark") was determined by a group of six panelists using the National Pork Producer Council's Japanese pork fat color standards. All belly fat samples were analyzed to determine complete fatty acid profiles. Iodine value and mean melting point were calculated using fatty acid data from each sample.

As shown in Table 5, pigs fed the 10% DDGS grew equally well, consumed less feed, had better feed conversion and had lower feed cost per pound of gain compared to pigs fed the corn/soybean diets without DDGS. At slaughter, there were no differences in carcass weight, back fat thickness or percentage of ham, loin, and belly relative to total carcass weight (Table 6). In addition, there were no differences in loin depth or percentage of lean muscle in the carcasses between the two groups. These results are in agreement with the growth performance and carcass composition results obtained in our initial study, and clearly show that feeding corn-soybean meal diets containing 10% DDGS has no negative impact on growth performance and carcass characteristics of grower-finisher pigs. In fact, the producer who fed the DDGS diets in this study obtained the same carcass quality at a lower feed cost per pound of gain compared to the producer who fed diets without DDGS.

When we evaluated the composition and quality characteristics of belly fat from these pigs, we saw no difference in color score based upon Japanese pork fat quality standards (Table 7), nor were there any differences in mean melting point of the belly fat. However, bellies from pigs fed the 10% DDGS diets had a higher iodine value than pigs fed the diets without DDGS. This is also in agreement with the results we obtained in our first study (Table 4). The iodine values are similar and are below the suggested maximum threshold of 70. These results clearly show that feeding diets containing 10% DDGS to grower-finisher pigs have negative effects on pork fat quality. As expected, the levels of linoleic acid, polyunsaturated fatty acids and omega 6 fatty acids increase in belly fat when pigs are fed diets containing 10% DDGS, but are well within accepted standards of acceptable pork fat quality.

Table 5

Growth Performance, Feed Usage and Feed Cost of Grower-Finisher Pigs Fed Diets Containing 0% or 10% DDGS

	0% DDGS	10% DDGS
ADG, lbs.	1.81	1.84
ADFI, lbs.	4.94	4.62
Feed/Gain	2.73	2.54
Lbs Feed/Head	570	554
Feed Cost/Lb Gain, $	0.17	0.16

Table 6

Carcass Characteristics of Grower-Finisher Pigs Fed Diets Containing 0% or 10% DDGS

	0% DDGS	10% DDGS
Carcass weight, lbs.	212	210
Last rib backfat, in.	1.09	1.11
Tenth rib backfat, in.	1.01	0.99
Ham, %	11.74	11.74
Loin, %	7.93	7.91
Belly, %	10.51	10.41
Loin depth, in.	2.72	2.72
% Carcass lean	56.36	56.47

Table 7

Mid-Belly Fat Quality Characteristics of Carcasses from Grower-Finisher Pigs Fed Diets Containing 0% or 10% DDGS

Measurement	0% DDGS	10% DDGS
Japanese fat color score	1.76	1.81
Mean melting point, °C	29.3	28.7
Iodine value	66.7[a]	68.3[b]
Oleic acid (18:1), %	47.39[c]	45.12[d]
Linoleic acid (18:2), %	11.94[c]	13.98[d]
Saturated fatty acids, %	33.99	34.26
Monounsaturated fatty acids, %	51.78[c]	49.47[d]
Polyunsaturated fatty acids, %	14.02[c]	16.11[d]
Total omega 3 fatty acids, %	0.98	0.96
Total omega 6 fatty acids, %	13.02[c]	15.14[d]
Omega 6:omega 3 ratio	13.28[c]	15.78[d]

[a, b] Means within row with unlike superscripts are different ($P < .05$).
[c, d] Means within row with unlike superscripts are different ($P < .0001$).

Conclusion

Based upon our research results, there is no reason for concern when feeding grower-finisher diets containing 10% DDGS on carcass or pork quality. The composition of some fatty acids (e.g., noleic acid, polyunsaturated fatty acids and omega 6 fatty acids) in pork fat increase with the addition of DDGS to corn/soybean meal diets, but does not alter the acceptability of pork based upon current industry standards. Furthermore, there is no evidence suggesting that feeding grower-finisher pigs diets containing 10% DDGS will decrease the quality and acceptability of U.S. pork in the Japanese export market. The studies we are currently conducting will help us better understand if we can feed higher dietary levels (20% or 30%) of DDGS to grower-finisher swine without negatively impacting pork fat quality and consumer acceptability of U.S. pork. **DGQ**

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