Use of low-test-weight corn in swine diets and the lysine/protein relationship in corn

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Summary: *Poor growing conditions throughout the corn belt in recent years have produced a high proportion of low-test-weight (bulk density) corn. Nutritionists expect low-test-weight corn to be higher in protein and lower in energy compared with corn of normal test weight (72 kg per hl; 56 lb per bu). Recently, several research groups have evaluated the effect of low-test-weight corn on performance of growing-finishing pigs. Researchers at South Dakota State University reported an inverse relationship between the test weight of corn and digestibility of protein and dry matter with no effect on digestibility of acid detergent fiber (ADF) and neutral detergent fiber (NDF). In a companion study, daily weight gain was not different between pigs fed low (59 kg per hl; 46 lb per bu) compared with normal test weight corn. Four additional studies have reported no detrimental effects on growth performance of pigs when corn with test weight as low as 40 lb per bu was fed. No studies have investigated the effects of low-test-weight corn on performance of breeding swine. Assuming that mycotoxins and such factors as molds and overheating are not compromising corn quality, low-test-weight corn seems to be comparable in feeding value to normal-test-weight corn for pigs.*

Several researchers have attempted to predict lysine content of corn using crude protein concentration. However, the poor relationship between lysine and crude protein concentration (r = .64 to .73) of corn limits the utility of this application. In most practical situations, reformulating swine diets to account for higher protein content of low-test-weight corn is of limited value.

The poor weather conditions for growing corn in many parts o f the United States in 1992 and 1993 forced swine producers to harvest corn with lower-than-normal test weight (bulk density). Previous general recommendations were to avoid using low-test-weight corn in swine diets. The concentrations of protein, fiber, and minerals usually increase and concentrations of starch and fat decrease as test weight of corn declines. This results in a higher-protein, lower-energy grain than corn of normal test weight (72 kg per hl; 56 lb per bushel). Research conducted with chickens has demonstrated that reductions in test weight resulted in a slight reduction in the true metabolizable energy content of corn.[1] Since corn's primary contribution to swine diets is energy, we generally think that low-test-weight corn is of lower feeding value than normal-test-weight corn. However, the 1992 corn crop did not exhibit nutrient content typical of low-test-weight corn. Field observations failed to demonstrate a consistent relationship between test weight and the crude protein or lysine content of corn. This inconsistent relationship and the recent prevalence of low-test-weight corn has led several research groups to question the previously held notion that low-test-weight corn was of lower feeding value for pigs compared with normal-test-weight corn. This paper will examine the effect of low-test-weight corn on pig performance and the relationship between lysine and crude protein in corn.

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Recent research related to test weight

At the University of Minnesota's West Central Experiment Station, we compared corn harvested in 1991 that had a test weight of 73 kg per hl (57 lb per bu) with corn harvested in 1992 dried to three moisture levels.[2] Test weight of the 1992 corn ranged from 61.2 to 63.8 kg per hl (47.5–49.5 lb per bu). Standard grower (77.6% corn, 19.4% soybean meal, 3.0% vitamins and minerals) and finisher (83.6% corn, 13.9% soybean meal, 2.5% vitamins and minerals) diets were formulated to contain 0.78% and 0.63% lysine, respectively. The 1991 corn contained 0.25% lysine while the low-test-weight corn contained between 0.25% and 0.26% lysine. Pigs began the experiment at an average weight of 35 kg (77 lb) and ended the experiment at 104 kg (229 lb). There was no significant difference in daily gain of pigs fed normal corn compared with those fed low-test-weight corn at 10% or 13% moisture (Table 1). Low test weight corn at 16% moisture did depress ($P < .01$) weight gain of pigs compared with normal corn, probably due to the higher moisture content of this diet (14.4% versus 9.1%). There was no significant difference in feed intake or feed efficiency between normal and low-test-weight corn.

Researchers at Michigan State University[3] studied the effects of corn test weight on performance of growing pigs. Test weights evaluated ranged from 54–76 kg per hl (42–59 lb per bu). Pigs began the 4-week trial weighing 13 kg (29 lb). They reported no effect of test weight on growth performance of pigs (Table 2). The

diet containing corn with a test weight of 61 kg per hl (47 lb per bu) did reduce growth rate and daily feed intake significantly. However, retrospective analysis of corn revealed that 2 ppm vomitoxin was present in this corn source, which probably was responsible for the depression in feed intake and growth performance associated with this diet.

Hansen, et al.,[4] reported improved digestibility of dietary crude protein and dry matter in growing pigs (40 kg body weight) as bulk density of corn declined. Digestibility of acid detergent fiber (ADF) or neutral detergent fiber (NDF) was unaffected by test weight of corn. In a companion growth trial, improved digestibility of lower-test-weight corn did not improve growth performance of growing pigs. Average daily gain of pigs fed low-test-weight corn (46 lb per bu) was similar to pigs fed normal corn (56 lb per bu; 1.78 versus 1.76 lb per day). Furthermore, studies using growing-finishing pigs in South Dakota[5] (Table 3) and nursery pigs in Canada[6] (Table 4) showed no consistent effects of corn test weight on pig performance.

Table 1

Effect of test weight of corn on performance of growing-finishing pigs—Minnesota[2]

Trait	1991 corn	1992 corn % moisture 10	13	16	SE
No. of pens	4	4	4	4	
Test wt., lb/bu	57	49.5	47.5	48.5	
Feed moisture, %	9.1	9.7	12.1	14.4	
Gain, lb/d	1.65	1.58	1.63	1.49[a]	.02
Feed intake, lb/d	5.69	5.50[b]	5.81[b]	5.47[b]	.10
Feed/Gain	3.46	3.48	3.57	3.69	.08

[a]Different from 1991 corn ($P < .01$).
[b]Quadratic effect within 1992 corn ($P < .10$).

Table 2

Performance of growing pigs fed corn of varying test weights—Michigan[3,a]

Trait	Test weight, lb/bu 42	47	51	59
Gain, lb/d	1.43[b]	1.32[c]	1.41[b]	1.41[b]
Feed intake, lb/d	2.91[b]	2.69[c]	2.87[b]	2.84[b]
Gain/feed	.49	.50	.49	.49

[a]Initial pig weight = 29 lb (13 kg); 4-week trial
[b,c]Means within a row with unlike superscripts differ ($P < .05$).

Table 3

Performance of growing-finishing pigs fed corn of varying test weights—GTA Feeds, South Dakota[5,a]

Trait	Test weight, lb/bu 40	45	50	55
Gain, lb/d	1.76	1.76	1.71	1.77
Gain/feed	.33	.32	.33	.34

[a]Initial pig weight = 43 lb (19.5 kg); final weight = 252 lb (114 kg).

Table 4

Performance of nursery pigs fed corn of varying test weights—Ontario[6,a]

Trait	Test weight, lb/bu 43.6	43.7	45.7	50.6	57.4	58.7
Gain, lb/d	1.06	1.32	1.12	1.30	1.21	1.26
Gain/feed	.39	.43	.42	.42	.42	.40

[a]Initial pig weight = 18.5 lb (8.4 kg); 3-week trial

Relationship of crude protein and lysine in corn

The crude protein (CP) content of corn is variable. Many factors such as soil type, variety, fertilization rates, moisture availability, and bushel weight affect the protein content of corn. Because crude protein is variable, one might also expect the lysine content of corn to be variable. Since swine diets are formulated on a lysine basis, this variability in lysine content of corn presents challenges to nutritionists as they attempt to formulate diets for optimal performance. A simple and obvious solution is to analyze corn for its lysine content and formulate diets accordingly. Unfortunately, lysine analyses are too time consuming and expensive to conduct on a regular basis. This is especially true when one considers the large volume of corn, the heterogeneity of corn sources, and the number of corn suppliers to commercial feedmills and swine units. A reasonable alternative to lysine analysis is to analyze corn for its crude protein content and use protein content to predict lysine content. Laboratory analysis of crude protein is fast and relatively inexpensive. For this approach to be viable, there must be a consistent, predictable relationship between crude protein and lysine content of corn.

Several studies have been conducted to investigate the relationship between crude protein and lysine content of corn. As protein content of corn rises, lysine content also increases but at a rate slower than the increase in protein. Consequently, lysine as a percentage of the protein declines with increasing protein content of corn. The relationship of crude protein to lysine is not in a constant 1:1 relationship because the proteins deposited during the late development of corn are lysine deficient compared with the lysine-rich proteins deposited early in development of the corn grain.[7]

The inaccuracy of proportional adjustments in lysine content, relative to crude protein levels, led researchers to develop re-

gression equations for predicting lysine content from crude protein content of corn. Cromwell, et al.,[8] found a significant correlation (r = .71) between protein and lysine content of corn. The North Central Regional Committee on Swine Nutrition (NCR-42)[9] recently calculated a regression equation for corn sampled in 2 separate years (Table 5; Figure 1). Likewise, Ward reported a similar equation at a Degussa Technical Symposium (Table 5).[7] Kerr and Wilson[10] determined amino acid content of corn harvested in 1993 representing seven states (26 samples). The relationship of crude protein and lysine of 1993 corn was not dramatically different than previous years. While some of these studies demonstrate a relationship between protein and lysine content of dent corn, the 'best' equations reveal that crude protein content only accounts for about 50% of the variation in lysine content.

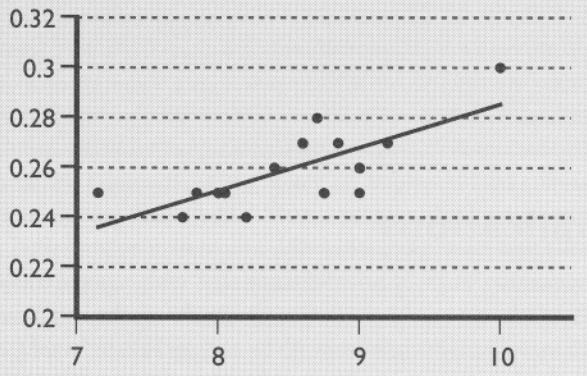
In contrast, Kornegay, et al.,[11] reported no significant relationship between crude protein and lysine content of dent corn. Similarly, other studies[12] have suggested that crude protein is a poor predictor of lysine content in corn (Figure 2). Given the variable success of researchers to accurately predict lysine content from crude protein content of corn, it would appear that routine adjustment of lysine content of corn based on protein content will not greatly increase the accuracy of diet formulations.

Table 5

Regression equations for predicting lysine content from crude protein content of corn

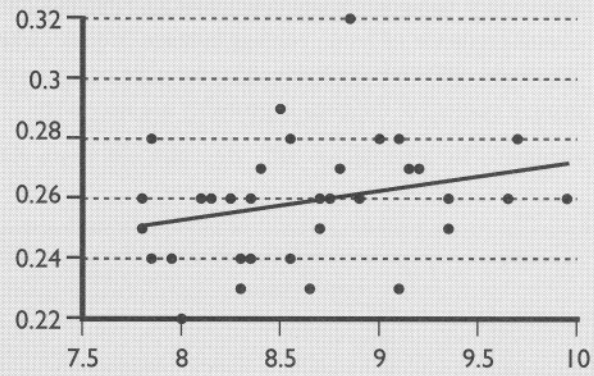
Source	Equation
NCR-42[9]	%Lys = 0.0172(%CP) + 0.1138; r = .73
Ward[7]	%Lys = 0.026(%CP) + 0.049; r = .66
Kerr and Wilson[10]	%Lys = 0.0205(%CP) + 0.1162; r = .64

Figure 1



Relationship of lysine to crude protein in corn, 1989–1990.[9]

Figure 2



Relationship of lysine to crude protein in Nebraska corn, 1987–1988.[12]

Practical considerations

From a practical standpoint, the central question is related to the need to alter dietary formulations to account for changes in lysine content of corn. Inherent in this question are two additional questions:

- what is the cost of making no adjustment? and
- how does corn lysine content influence final diet lysine concentration?

As protein content of corn increases, lysine content also increases at a rate slower than that of protein. Making no adjustment in the lysine value of high protein corn will result in a final diet that is slightly higher than desired in lysine. The cost of failing to make an adjustment in this situation would be lost opportunity to reduce the level of soybean meal or other protein supplement included in the diet. Making no adjustment when low protein corn is fed may result in a final diet that is lower than intended in lysine. If the cost of low or marginal lysine diets is very high (such as market price discounts for fatter market hogs), then one should consider using a lysine concentration for corn in the lower end of the expected range of lysine concentrations when formulating diets. This adjustment will force more soybean meal or other protein source into the diet. The cost of this additional soybean meal can be viewed as an insurance premium against the potential cost of market discounts for fatter carcasses at slaughter.

In the research cited above, lysine content of normal dent corn ranged from 0.20%–0.32% lysine. Most samples were between 0.22%–0.28% lysine. What effect does this range in lysine have on lysine content of a swine diet? The effects of corn lysine content would be most evident in a swine finisher diet because of the relatively high proportion of corn typically used. As lysine content of corn increases from 0.20%–0.30%, lysine content of the final diet will increase from 0.64%–0.72% lysine (Table 6). Final diet lysine concentration ranged from 0.66%–0.71% for corn containing between 0.22%–0.28% lysine. In most situations except the one cited above, this variation in final diet lysine content probably is not large enough to warrant serious alterations in diet formulation. Of course, the effects of corn lysine content on final diet lysine concentration will be less in other diets such as starter and lactation diets that use a lower proportion of corn and a higher proportion of soybean meal and other ingredients that tend to be more consistent in their lysine content.

Table 6

Effect of lysine content of corn on final diet lysine concentration

% lysine in corn	% lysine in finisher[a]
0.20	0.64
0.22	0.66
0.24	0.67
0.26	0.69
0.28	0.71
0.30	0.72

[a]81% corn, 15.75% soybean meal, 3.25% minerals and vitamins

Implications

- Assuming corn is not contaminated with mycotoxins, and other factors are not compromising the quality of the corn, low-test-weight corn seems to be comparable in feeding quality to normal-test-weight corn for pigs.
- Corn with test weight as low as 40 lb per bu can support pig performance at a similar rate to corn with test weights of 56 to 59 lb per bu.
- One cannot consistently use crude protein content as an accurate predictor of lysine content in corn. In most practical situations, adjusting the lysine value for corn based on crude protein content of the corn is probably not necessary.

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