PRAIRIE SWINE CENTRE

FEEDING FACTS: CORN

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Publication No. 080202

Summer 2002

OVERVIEW

Corn (Zea mays) sometimes referred to as maize and related products have been popular ingredients in swine diets for many years. Corn first became a popular swine ingredient in Ontario when new cultivars made it agronomically more feasible about 30 years ago.

The high yields achieved in areas capable of growing corn quickly translated into more pounds of pork per acre than barley and the switch to corn was thus inevitable. However, its early introduction was met with a certain degree of scepticism, due to concerns about carcass grades.

Proper diet formulation, and in particular maintaining proper amino acid to energy ratios, soon overcame such resistance. Pig diets based on corn, soybean meal and premix have become widely accepted and have become standards against which many alternative diets are compared. This does not imply that corn (and soybean meal) based diets should always be the diet of choice. In many parts of the world, equivalent performance is achieved in pigs fed diets that contain feedstuffs other than corn as compared to pigs fed corn-based diets. For example, starch in corn is not as well digested by young, newly weaned piglets as the starch in oat groats. However, corn is fed as the main feed ingredient in diets for millions of pigs and will continue to be a major feed ingredient in the future.

Because of its high energy content, pigs perform well on diets based on corn. Carcass quality is not impaired, as evidenced by the fact that average carcass indexes in Ontario or Quebec, where corn is the predominant grain, are no poorer than those in regions where corn is not used. The carcass fat from pigs fed on corn will be different than the fat of pigs fed wheat or barley; it will be slightly softer and perhaps yellower in colour.

The softer consistency reflects the content and quality of fat in corn. Corn contains approximately 3.5% fat which is substantially higher than that in barley and wheat that contain approximately 1.7% fat. The fat that is present in corn tends to be highly unsaturated and soft (oily) as well; the colour is due to the presence of a pigment called cryptoxanthin. In some parts of the world, this colour is considered undesirable and white varieties of corn are preferred.

Inside this issue:

Protein Content of Corn	2
Impact of Mycotoxins	2
Variation in Quality	3
Value of High-Oil Corn	4
Managing Low Test Weight Corn	5

Special Points of Interest:

- corn test weight does not significantly affect pig growth until it drops below 45 lbs/bu
- DE content of high-oil corn is 5% higher than from regular corn
- Lysine and tryptophan are the first and second limiting amino acids for swine

PROTEIN CONTENT OF CORN

The protein content in corn is low and has a less desirable amino acid profile than other grains. Lysine and tryptophan are the first and second limiting amino acids, respectively, for swine. The reason for the poor quality of the protein is that zein, the main storage form of protein in the kernel, is a poor source of many essential amino acids.

Corn	
Digestible Energy	3,550
Crude Protein	8.50
Lysine	0.26
Digestible Lysine	0.17
Digestible Threonine	0.21
Digestible Tryptophan	0.04
Calcium	0.02
Phosphorus	0.25

The amino acid content of corn can be predicted using regression equations based on crude protein.

Varieties of corn that are higher in protein and more specifically in lysine have been bred. The lysine content in these varieties is approximately 30% higher than in conventional corn. The In addition new varieties of corn with extremely high fat contents (up to 10%) is available in slected corn varieites. However, the DE content of these varieties may be as much as 5% higher than those in conventional corn.

MYCOTOXINS IMPACT ON FEEDING CORN

Perhaps the greatest concern surrounding the use of corn in swine diets is its susceptibility to molds, especially when wet weather arrives during critical growing stages. The actual mold does not appear to be the problem; the fungi may consume some nutrients in the kernel, but the effect on feed quality is questionable. Corn so moldy that the kernels could hardly be separated, has been fed to pigs with no adverse affects on performance. However, when the mold produces a mycotoxin, such as vomitoxin or zearalenone, the effects on swine can be very serious. Reproductive performance of sows appears to be most susceptible, so that some pork producers have switched to barley-based diets for the breeding herd. This is not necessarily a practical solution, since barley can also be infected, and lactation diets based solely on barley as the basal grain may contain insufficient energy to support maximum milk production.

> The effect of mycotoxins in corn to fed to swine have the greatest concern in reproductive performance of sows

If a suspected outbreak of mycotoxicosis occurs, there is reason to believe that an increase in the nutrient (energy, protein and vitamin) content of the diet will be beneficial. Minimizing other stressors in the environment is also helpful since the pig is less capable of dealing with them. A broad spectrum antibiotic at therapeutic levels is recommended for the same reason. The best course of action is to remove the suspect feed until a proper analysis has been carried out to determine if mycotoxicosis is the cause of the problem. A variety of feed additives are have been evaluated as potential treatments for mycotoxicosis. To date, these have shown only marginal improvements

Corn normally must be artificially dried to prevent deterioration during storage or stored as a wet grain, either treated with a preservative or held In an oxygen limiting structure. Drying of corn must be carefully controlled to prevent loss of nutritive value. Research has shown that drying corn at temperatures of up to 110^{0}C to a final moisture content of 12-15% will have no effect on pig performance. Exceeding 150^{0}C drying temperature will reduce acceptability to the pig.

For more information on corn and mycotoxins please visit the Alberta Agriculture, Food, and Rural Development Website:

http://www.agric.gov.ab.ca

VARIATION IN CORN QUALITY

On a dry matter basis, there is little difference in the nutritive value of high moisture or dry corn with the exception phosphorus is more available from high moisture corn. Vitamin E tends to degrade faster in high moisture corn than in dry corn. Higher fortification with vitamin E may be required in high moisture corn based diets. Otherwise, the decision of which storage method to use will depend on the relative costs and convenience of the two systems.

As with other cereal grains, variation in the feeding value of different samples of corn, due to differences in variety, growing, harvesting, and drying conditions can be expected. However, little research has been conducted to determine variation in feeding value of different samples of corn.

Based on research with chickens, which are more sensitive to changes in feeding value than pigs, it can be concluded that corn bushel weight is a poor indicator of feeding value of individual corn samples. This is supported by the observations made on starter pigs. These results suggest that some samples of immature dried corn with an extremely low bushel weight can support levels of performance similar to that in pigs fed regular corn. Unlike in barley and wheat, fibre levels in corn are generally low and do not vary much between samples. Fibre is thus also a poor predictor of feeding value of corn samples. The best predictor of feeding value may be the starch content. In high fat corn varieties, the fat content should be considered as well. In regular corn, the starch content is approximately 60%, while it may be as low as 50% in some samples of corn.

Nutritional Value of Immature Corn for Starter Pigs Fed Corn-Soymeal Based Diets

	Bulk Density (lbs/bu)	Gain (kg/day)	Feed Intake (kg/day)	Feed Conver-
Control 1	7.4	.50	1.32	2.40
Control 2	8.7	.57	1.42	2.49
Variety A	0.6	.59	1.38	2.34
Variety B	3.7	.60	1.41	2.35
Variety C	3.6	.48	1.24	2.58
Variety D	5.7	.51	1.23	2.41

COMPARISON OF CORN-BASED DIETS

Ingredient	Diet 1	Diet 2	Cost/mt
Wheat	72.938*	0	$202
Barley	0	20.873	$207
Corn	0	48.014	$195
Soymeal	22.618	26.612	$355
Mono/dical	1.173	1.422	$473
Canola Oil	1.00	1.00	$890
Limestone	0.891	0.702	$63
Salt	0.400	0.400	$138
Vitamin	0.400	0.400	$1,400
Mineral	0.400	0.400	$580
Lysine	0.168	0.160	$2,450
Threonine	0.012	0.017	$5,300
Totals	**$255.88/mt**	**$260.68/mt**	

*Note: Expressed as a total percent of the diet

VALUE OF HIGH-OIL CORN

Introduction

High-oil corn is used as a source of nutrients, especially energy, to meet requirement of pigs. In the present study, DE content and digestibility of energy and amino acids of high-oil corn was characterized and related to chemical characteristics.

The DE content of high-oil corn was 5% higher than from regular corn. Corn DE content could be predicted using gross energy (GE) or oil content. High oil corn is clearly a source with a high DE content.

Results and Discussion

In high-oil versus regular corn, oil content was 4.2% higher (9.1 vs 4.9%), resulting in a 6% higher GE content (4853 vs 4589 kcal/kg DM), and protein content was 9.5 versus 9.1%, acid-detergent lignin 0.51 versus 0.41%, and starch 68.2 versus 71.3%.

Total tract energy digestibility was 1.1% lower (87.4 versus 88.3% in high-oil versus regular corn; however, DE content was 5% higher in high-oil versus regular corn (4238 versus 4052 kcal/kg DM). The DE content could be predicted using single-regression by corn GE (R^2 = 0.93), oil (R^2 = 0.90; Figure 1), and protein (R^2 = 0.49). Ileal E digestibility was similar (75.4 vs 76.4%) between high-oil versus regular corn; however, ileal DE content was 4% higher in high-oil versus regular corn (3660 versus 3503 kcal/kg DM).

Nutritional Value of Selected Feed Ingredients

	Barley	Hulless Barley	Corn	Naked Oats	Wheat
Energy, kcal/kg					
Digestible	3,100	3,400	3,550	3,600	3,425
Metabolizable	2,960	3,210	3,360	3,420	3,240
Proximate Analysis%					
Crude Protein	10.6	13.7	8.5	12.2	13.5
Crude Fiber	5.1	3.6	2.2	3.6	2.7
Acid Detergent Fiber	7.1	1.2	3.4	3.7	3.5
Neutral detergent fiber	17.8	10.1	12.0	9.9	10.8
Total Amino Acids%					
Lysine	0.39	0.54	0.26	0.50	0.40
Threonine	0.36	0.47	0.31	0.40	0.40
Methionine	0.17	0.24	0.19	0.20	0.24
T.S.A.A.	0.40	0.47	0.37	0.54	0.57
Tryptophan	0.14	0.16	0.06	0.15	0.16
Isoluecine	0.42	0.45	0.32	0.50	0.53
Luecine	0.80	0.95	1.04	0.90	0.89
Valine	0.58	0.62	0.46	0.70	0.56
Phenylaline	0.60	0.76	0.40	0.65	0.56
Arginine	0.50	0.64	0.45	0.80	0.61
Histidine	0.24	0.30	0.21	0.27	0.26
Apparent Ileal Digestible Amino Acids					
Lysine	0.27	0.37	0.17	0.35	0.29
Threonine	0.23	0.30	0.21	0.24	0.28
Methionine	0.13	0.18	0.16	0.16	0.20
Cystine	0.17	0.17	0.14	0.27	0.27
Tryptophan	0.10	0.11	0.04	0.11	0.13
Isoluecine	0.31	0.33	0.25	0.40	0.44
Valine	0.41	0.44	0.36	0.55	0.44

In Figure 1, equations to predict corn GE, DE, and ileal DE content using corn oil content are presented. The figure clearly illustrates the large range in corn oil content and the positive effects of increased oil content on corn DE content.

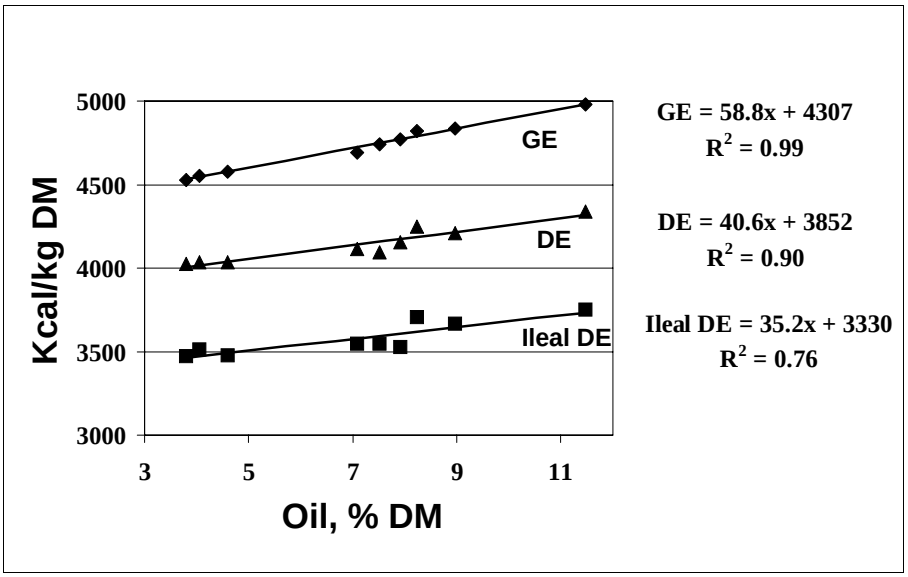
Apparent ileal digestibility of lysine was 2.4% higher in high-oil versus regular corn (64.0 versus 61.6%), al-

though less difference was observed in standardized digestibility of lysine (76.3 versus 75.5%). The increase in oil content within each near-isogenic sample pair was related (R^2 = 0.47) to an increase in apparent ileal lysine digestibility.

Implications

In summary, feeding high-oil versus regular corn does result in more energy and amino acid that are available to the pig to support metabolic functions.

Figure 1. Effect of Corn Oil Content (% DM) on Energy Content (kcal/kg). To determine corn gross energy (GE), DE, or ileal DE, determine its oil content and use the provided equations



MANAGING LOW TEST WEIGHT CORN

Some researchers have concluded that corn test weight does not significantly affect pig growth until it drops below 45 lbs/bu, corn that they refer to as very low test weight corn. They suggest that as test weight declines below 45 lbs/bu, digestible energy decreases by 5-6 % and as a result, feed efficiency and growth rate also suffers (3-10%) because of reduced energy intake. Still others suggest that corn with test weight as low as 40 lb/bu can support similar performance to corn with normal test weight. Research at South Dakota State University and elsewhere has shown that adding 2-3% oil or fat to diets made with very low test weight corn helps improve performance, but does not return it to the level achieved with normal test weight corn.

Research has determined that low test weight corn tends to be higher in crude protein, fiber and ash and lower in fat and starch than normal corn. Besides energy, the level of lysine and crude protein is likely to be lower in very low test weight corn because the corn has not had the chance to completely assimilate amino acids. In addition, the crude protein value in very low test weight corn is extremely variable and should be tested. Corn with test weights above 45 lbs/bu, may also have variable crude protein content and requires close monitoring. However, normal published averages for lysine (0.25%) in low test weight corn should be relatively constant.

Pig Performance at Different Corn Test Weights

	Light Corn 41 lbs/bu	Medium Corn	Heavy Corn 54 lbs/bu
Average Daily Gain	0.73	0.77	0.79
Average Daily Intake	2.68	2.93	2.82
Feed:Gain Ratio	3.56	3.82	3.56

To deal with low test weight corn, producers should:

- Test corn for moisture and protein.
- Determine bushel weight of corn at 15% moisture.
- Balance rations to account for differences in protein, energy and moisture.
- Recalibrate volumetric mix mills to compensate for lower bushel weights.
- Most importantly, remember that if you work in weight of corn, not volume, or adjust accordingly, you shouldn't have a problem.

Source of this information can be found at: .
http://www.gov.on.ca/OMAFRA/english/livestock/swine/facts/info_n_summary.htm

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FREQUENTLY ASKED QUESTIONS?

Q **What factors must I consider in diet formulation when switching from barley and wheat to corn as my main energy source?**

A The main difference revolves around the fact that corn has 15% more energy than barley and 4% greater than wheat, while at the same time being lower in protein than both of these barley and wheat. Step 1 is to have a qualified nutritionist reformulate your diets for corn, do not just substitute one grain for another. Step 2 recognize that while Lysine is the first limiting amino acid in all of these diets, the second limiting amino acid in a corn diet is Tryptophan while for small grains this is Threonine. Again, only a qualified nutritionist can formulate the diet to avoid errors in this area. Step 3 the mineral composition of the grains is also different, requiring a new premix blend.

Q **What screen size should I use to grind corn?**

A Maximum nutrients can be extracted by the digestive system from grains that are finely ground. Regardless of grain type, research has shown that optimum digestion and minimum digestive disorders are achieved when a particle size of 650-750 microns is achieved. Although a 1/8" screen is the most common size for small grains to achieve this particle size, screen size alone does not determine particle size. Particle size can vary with the type of grain, moisture levels, age/wear of hammers and screens, power of the mill etc. When grinding corn, or any grain, make sure to check the final particle size rather than relying on screen size selection.

Q **Can I roll corn instead of grinding?**

A Yes. Corn can be rolled and this practice is used extensively in the US because of the lower energy requirements associated with rolling versus grinding. Again, the end result of achieving an average particle size of 700 microns is important criteria when choosing the processing method.

Q **What tests can I perform on corn to verify I am getting the quality I need?**

A Tests can be divided into two broad categories; nutrient quantity and the presence or absence of molds and mycotoxins. Nutrient testing must include analysis for moisture, protein and fat. Two groups of toxins are of concern, fusarium and vomitoxin and commercial tests are available for both. Mold tests are also available but test only for mold, which is not necessarily harmful unless that mold has produced mycotoxins.

Q **How do I know it is economical to feed corn?**

A Diets are developed for different weight ranges of pigs. These diets have specifications for energy, amino acids, vitamins and minerals. The appropriate substitution of one grain source for another is dependent on the price per unit of nutrient (such as energy or lysine). The only way to know when to move from one grain source to another is to frequently formulate diets for least cost.

Q **Can I feed corn as the only grain source to my breeding herd?**

A Yes. Since corn diets are higher in energy than barley based diets you will feed less to a dry sow if the diet is corn based. Nursing sows can benefit from a corn-based diet since it supplies more energy per kilogram than a barley diet and can meet the energy needs when appetite may be limiting.

Q **Will I notice any difference in the barn when I switch from barley to corn-based diets.**

A Corn has less fiber than small grains and you will notice that manure in gutters stays better in suspension. Conversely, in the earthen manure storage, the crust that forms partially from grain hulls may be less distinct.