Pork Industry Nutritional Efficiency Consortium Research

2007 - 2011

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Letter from the President

Dear Fellow Pork Producer:

The economic challenges we have faced in the past year are really a culmination of factors that started in 2007 when the price of feed ingredients began its rapid rise. Traditionally, between 65 and 70 percent of the cost of production was directly related to feed cost. However, we've seen feed costs rise dramatically to where they now represent more than 70 percent of the cost of production. Combined with severe and widespread drought conditions in the Corn Belt during the 2012 growing season, the role research plays has never been more important than it is today. From gaining a better understanding of the use of alternative feed ingredients in swine diets to improving feed nutrient utilization, research plays a critical role in how we can continue to have a vital U.S. pork industry.

As representatives of your Pork Checkoff, we are committed to finding practical solutions to reducing feed cost and improving nutrient utilization. Whether it's finding ways to reduce feed usage in the short-term or gaining a better understanding of how dietary ingredients interact with swine physiology, Checkoff is involved with the leading edge of this research on your behalf.

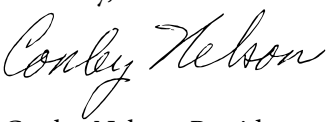
This Checkoff publication, ***Pork Industry Nutritional Efficiency Consortium Research 2007 - 2011,*** contains key findings and applications for improving nutritional efficiency based on research funded through this consortium representing pork producers and allied industry.

Examples of how pork producers can apply this nutritional efficiency research include:

- Incorporating alternative feedstuffs into swine diets to mitigate the high cost of feed while maintaining animal performance and pork quality
- Understanding the impact of feed processing and enzyme utilization on enhancing nutrient availability
- Considering the key role genetics and the breeding herd play in improving whole-herd nutritional efficiency

As a producer, I find this resource to be a useful consolidation and summarization of the research that has been funded through the Nutritional Efficiency Consortium. This research has advanced our understanding of how to utilize alternative feed ingredients in swine diets and it provides critical information about extracting nutrients in feed more efficiently. If you'd like to learn more about these and other Checkoff-funded research programs, please visit pork.org/research.

Sincerely,



Conley Nelson, President
National Pork Board

Introduction

Nutritional Efficiency Consortium Research, 2007-2011

Purpose: The information in this booklet is intended to provide a comprehensive resource that summarizes the outcome of research projects that were funded through the pork industry's Nutritional Efficiency Consortium. It offers producers, swine nutritionists, consultants and researchers a reference resource and knowledge about improving nutrient utilization to better support animal maintenance, growth and production. To view all the Checkoff-funded nutrition research, visit *www.pork.org/research.*

Introduction: The economic challenges U.S. pork producers have faced since 2007 underscore the importance of research to better understand use of alternative feedstuffs and how to more efficiently extract nutrients from swine diets. Given today's market situation, feed makes up more than 70 percent of the cost of production so even small improvements in efficiency can improve profitability. The pork industry's Nutritional Efficiency Consortium was established in 2007 to serve as a vehicle for identifying areas of need and consolidating research related to improving swine diets by making better use of nutrients. This consortium is made up of representatives from the pork industry but also includes wide representation of a broad sector of the allied industry. A listing of the consortium participants can be found in Table 1. The need for this consortium was identified as a direct result of the increased use of alternative feed ingredients to meet the nutritional requirements of various classifications of swine as economically as possible. Therefore, the specific objectives of the consortium were to:

1. maximize production efficiencies through improved feed conversion and reduced/optimized feed costs
2. assist producers in lowering feed costs through improved feeding technologies and information about the use of lower-cost alternative diet ingredients
3. develop comprehensive research programs to enhance genomic and cellular level nutrient utilization processes and capabilities in the pig.

When the consortium was formed it was recognized that, in the future, pigs in the United States would be fed diets that would be significantly lower in energy and higher in fiber compared to a more traditional corn-soybean meal diet. However, there was relatively little scientific information available for producers, nutritionists and consultants to rely on when formulating swine diets or making dietary recommendations. A total of 43 projects that address the research priorities of the consortium have been funded since the formation of the consortium (see Table 2). The value of swine diets goes beyond the $2 million of research directly funded by this consortium, and the hundreds of thousands of dollars more in coordinated research projects. The real value to the industry is having science-based, objective information about the uses and implications of feeding alternative feedstuffs. Even as this research has given pork producers better tools to improve efficiency, the knowledge builds on itself with new questions and opportunities as we learn more. Additionally, graduate and undergraduate students have been supported through these funding efforts ensuring a viable research infrastructure into the future.

Finally, this consortium has expanded the available dollars to support research in this area. Since 2007, the Checkoff has committed just over $1.2 million to this effort while other contributions have added slightly more than $1 million. Leveraging funds in this way benefits not only the consortium participants, but also the U.S. pork producers because it allows their Checkoff dollars to support a greater breadth and depth of research.

Disclosure: The information pertaining to specific research projects in this report have been edited in an attempt to highlight the most relevant points. The full industry summaries, and in many cases, the full research reports, can be found by visiting the website at *www.pork.org/research.*

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Nutritional Efficiency Consortium Participants

One of the purposes behind formation of the Nutritional Efficiency Consortium was to bring together diverse groups that have a stake in the nutrition and feeding of pigs. These stakeholders represent state and national checkoff-funded organizations as well as private industry. Without the generous contributions of consortium participants, the amount of research conducted in this area from 2007 to 2011 would have been greatly reduced.

Nutritional Efficiency Consortium Participants

- Arizona Pork Council
- AgriSolutions, Inc.
- DPI Global
- Eli Lilly/Elanco
- Iowa Corn Growers Association
- Iowa Pork Producers Association
- Illinois Corn Marketing Board
- Illinois Pork Producers Association
- Kansas Corn Commission
- Kansas Pork Association
- Lucta USA
- Minnesota Pork Board
- Missouri Pork Producers Association
- Monsanto
- Mississippi Pork Producers Association
- Montana Pork Producers Council
- National Corn Growers Association
- National Pork Board
- North Carolina Pork Council, Inc.
- Nebraska Corn Board
- Nebraska Pork Producers Association, Inc.
- Ohio Pork Producers Council
- Pioneer Hi-Bred International, Inc.
- Utah Pork Producers Association
- Wisconsin Pork Association

Acronyms Commonly Used in this Report

AA	Amino Acid	Lys	Lysine
AID	Apparent Ileal Digestibility	ME	Metabolizable Energy
ATTD	Apparent Total Tract Digestibility	N	Nitrogen
BW	Body Weight	NE	Net Energy
DDGS	Dried Distillers Grains with Solubles	P	Phosphorus
DE	Digestible Energy	RFI	Residual Feed Intake
DM	Dry Matter	SID	Standardized Ileal Digestible
GE	Gross Energy	TDF	Total Dietary Fiber
HP-DDGS	High Protein Dried Distillers Grains with Solubles	TID	True Ileal Digestible
IV	Iodine Value		

Research Projects funded through the Nutritional Efficiency Consortium

One of the purposes of the Nutritional Efficiency Consortium was to consolidate the research effort in this area. Of the more than 135 proposals submitted in response to five calls for proposals, 43 were selected based on both scientific merit and application to the industry. This selection process was carried out by scientific peers as well as the National Pork Board's Animal Science Committee which is comprised of pork producers with a diverse demographic profile. The following table contains a listing of the proposals which were selected for funding in ascending order based on the National Pork Board identification number. The table also details the investigator who conducted the work, the title of the project and the page number where the project can be found in this publication.

Research Projects Funded Through the Nutritional Efficiency Consortium

ID and Investigator	Title	Page
07-143 Shurson, Gerald	Energy and amino acid digestibility of corn distillers syrup by-products in growing pigs	11
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07-172 Stein, Hans H.	Net energy of three sources of distillers dried grains with solubles fed to growing pigs	11
07-173 Stein, Hans H.	Critical review of literature on feeding bio-fuels co-products to pigs	9
08-004 Johnston, Lee J.	Interactive effects of DDGS and housing system on sow performance and longevity	22
08-015 Shurson, Gerald	Assessment of the effects of diets containing DDGS with supplemental tallow on fat digestibility, growth performance, carcass and fat quality in growing-finishing pigs	18
08-075 Cammack, Kristi	Effects of Dietary Aflatoxin on Hepatic Gene Expression in Swine	31
08-093 Zhang, Yanhong	Sulfur Concentration in Distiller's Dried Grains with Soluble (DDGS) and Its Impact on Palatability and Pig Performance	20
08-094 Cromwell, Gary L.	Characteristics and Eating Quality of Bacon, Sausage, and Boneless Chops from Finishing Pigs Fed Medium and High Levels of Distillers Dried Grains with Solubles (DDGS)	19
08-107 Kerr, Brian	In vitro estimation and in vivo determination of metabolizable energy in corn co-products	12
08-111 Kerr, Brian	Critical evaluation of commercially available enzymes, and processing on nutrient digestibility of swine diets containing DDGS	28
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08-115 Stein, Hans H.	Ileal and total tract apparent and true digestibility of fat in distillers dried grains with solubles and other corn oil products fed to growing pigs.	15
08-174 Ellis, Michael	Development of equations to predict the metabolizable energy content of corn distiller's dried grains with solubles from a wide variety of sources	12
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09-014 Latour, Mickey	Evaluation of the Pork Quality of Sows Fed Diets with different levels of Distillers Dried Grains	23
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09-037 Shurson, Gerald	Impact of DDGS Particle Size on DM, Energy, Nitrogen, and Phosphorus Digestibility in Diets for Growing Pigs	28
09-044 Shurson, Gerald	Effects of rapid introduction and removal from the diet of high and low quality corn distillers dried grains with solubles (DDGS), and dietary inclusion rates on growth performance and carcass characteristics of growing-finishing pigs.	17
09-051 Dekkers, Jack C.M.	Effect of selection for feed efficiency during the growing period on sow feed efficiency and reproductive performance	26
09-109 Cromwell, Gary L.	Methods of Restoring Carcass Firmness and Other Post-Harvest Traits in Finishing Pigs Fed a High Level of Distillers Dried Grains with Solubles (DDGS)	19
09-119 Zhang, Yanhong	Fate of Lysine and Phytate During the Bioprocess of Making DDGS	10
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Q & A with Jerry Shurson

University of Mnnesota Extension Swine Nutritionist

Dr. Jerry Shurson is one of several investigators who conducted research projects funded through the Nutritional Efficiency Consortium. Recently, he was asked to provide answers to questions about nutritional efficiency. His responses to these questions provide insight on how nutritional efficiency differs from feed efficiency, factors that affect nutritional efficiency, the progress that has been made in our understanding of nutritional efficiency and his vision for research needs in the future.

Checkoff: Define nutritional efficiency and how it differs from feed efficiency.

Shurson: Traditionally, feed efficiency has been defined as the amount of feed necessary to produce a pound of live weight gain. We have used this as a primary economically important measure to evaluate feed utilization and feed costs. However, this definition is too general and is affected by many factors. In fact, many people argue that it is not a good indicator of profitability and is not an effective benchmark to use in pork production. First, feed efficiency tells us nothing about the composition of growth (lean and fat) and is affected by the energy and nutrient density of the diets. Furthermore, it is heavily influenced by mortality rates (especially in the finishing phase), physical form of the diets (particle size and pellets), starting weight and market weight and use of ractopamine.

Due to the record high costs of energy and amino acids in recent years, we need to think differently and use more specific, meaningful measures for the efficiency of energy and nutrient utilization of these major cost components in swine diets. Feed cost represents 65 to 70 percent of the total cost of production and energy represents 86 percent of feed cost. So, for every dollar spent on feed, $0.56 to $0.60 of that dollar is used to pay for the energy component. Because of this large contribution of energy to total feed and production cost, our primary focus for improving nutritional efficiency should be on energy utilization. Nutritional efficiency can be defined as improving the proportion of dietary gross energy and poorly digested nutrients present commercial pig diets into carcass lean to meet the biological capabilities of the genetics being used to produce pork. For example, we should be using measures like kcal of energy per pound of lean gain, rather than pounds of feed per pound of gain.

Checkoff: What factors have the biggest impact on nutritional efficiency today? Has that changed over time?

Shurson: I believe that the biggest factor has been swine nutrition research, and yes, funding for discovering and developing new knowledge has changed. Federal and state government funding to support fundamental swine nutrition at land grant universities has been nearly non-existent for many years. Fortunately, major investments made by the National Pork Board and some state pork boards have enabled researchers to partially meet some of these fundamental swine nutritional efficiency research needs.

One of the most powerful tools resulting from fundamental swine nutrition research for improving efficiency of nutrient utilization in commercial pork production has been the development and implementation of the Swine NRC Nutrient Requirement Models. The first model was developed and introduced in 1998, and a more comprehensive and updated version has just been made available through the 2012 Swine NRC. These models use a factorial approach for nutrient partitioning and account for nutrient utilization efficiencies in growing pigs as well as sows based on specific farm conditions. They also allow the use of the net energy system, standardized ileal digestible amino acids, and standardized total tract digestibility of phosphorus to determine nutrient requirements for specific farm conditions. Other notable technologies that have made major impacts on nutrient utilization efficiency in the U.S. pork industry include ractopamine and phytase.

Checkoff: At the farm level, what are the biggest things producers can do to improve nutritional efficiency?

Shurson: It can all be related back to getting the right feed to the right pigs at the right time, all of the time. There continues to be a significant gap between formulating optimal diets based on the best science available, and making sure pigs are actually eating the feed that they are intended to get. Attention to *all* of the details of feeding management is extremely important for optimizing nutritional efficiency. These include things such as adhering to feed budgets, minimizing feed interruptions, frequent adjustments of feeders to insure adequate feed intake without allowing feed wastage, and managing waterers for adequate water intake.

Checkoff: Looking back over your career, has the pork industry made small, medium or big strides in improving nutritional efficiency?

Shurson: The pork industry has made big strides but it depends on the standard that one uses for comparison. On one hand, ruminant nutritionists have been using the net energy system for formulating diets for many years, but the use of the net energy system in swine nutrition has only recently become a major focus in North America. We know that formulating diets on a net energy basis improves dietary energy utilization efficiencies and reduces feed costs. The U.S. pork industry has had the "luxury" of having an abundant supply of the least expensive corn and soybean meal in the world, which has allowed us to feed very simple high energy, low-fiber diets without much economic incentive to implement the net energy system to evaluate feed ingredients or formulate swine diets. Now, with the diversion of a significant amount of starch (corn) and fats/oils toward biofuels production, and the cost of feed energy at record levels, swine diets are becoming more complex and include more high-fiber, lower cost ingredients. In order to maximize dietary energy and nutrient utilization efficiencies, we need to understand the benefits and limitations of these alternative ingredients, as well as develop accurate and inexpensive ways to determine the net energy value of these more variable, high-fiber ingredients. The use of standardized ileal digestible amino acids, and standardized total tract digestibility of phosphorus for determining nutrient requirements, and formulating diets for specific farm conditions have been major advances for improving nutritional efficiency in U.S. pork production.

Checkoff: What research has your laboratory conducted that has led to improved nutritional efficiency?

Shurson: Thirteen years ago, we began evaluating the feeding value and benefits and limitations of DDGS in swine diets. At that time, very little of this byproduct was used in swine feeds and not much was known about its nutritional value for pigs. Therefore, we needed to start with basic evaluation of the feeding value of this ingredient. With significant research funding from the National Pork Board as well as state corn growers associations, our research group, as well as researchers at other universities, have conducted numerous studies to understand how to optimize the use of DDGS in swine diets. Today, nearly 20 percent of U.S. DDGS production is being used in significant amounts in swine feeds, and DDGS has become part of the "new normal" of feed ingredients used at relatively high inclusion rates in swine diets. With this new nutritional knowledge, as well as the abundant supply and cost competitiveness of DDGS relative to corn and soybean meal, pork producers have saved as much as $10 per pig in feed cost over the past two to three years by using this ingredient. We started with a relatively unknown alternative feed ingredient and through a series of research studies, have obtained enough information to utilize it as effectively as other feed ingredients, but still have more work to do to improve its nutritional efficiency value.

One of the ongoing challenges of using by-products from the ethanol industry is that production processes in ethanol plants continue to evolve. Now, the majority of U.S. ethanol plants are extracting up to 30 percent of the oil before making DDGS. This practice impacts the energy and feeding value of reduced-oil DDGS for swine. Dr. Brian Kerr (USDA-ARS) and I conducted an initial study where we developed ME prediction equations to use for estimating ME content of DDGS regardless of oil content and nutrient composition. With funding from the National Pork Board, we are now focusing on moving to the next tier of nutritional efficiency by conducting research to determine the net energy content of DDGS with variable oil and nutrient content. This is a good example of how we need to start with understanding the basics of a relatively unknown feed ingredient, and then continually build on our knowledge to get to the level of optimizing nutritional efficiency of this ingredient.

Our work is now more focused on obtaining more nutritional efficiency from DDGS and other alternative ingredients. For example, one of our other major research themes is to develop and evaluate "nutritional tools" such as near infrared technology applications and various in vitro procedures for estimating ME and NE content of DDGS and other feed ingredients as well as standardized ileal digestible amino acids. Dr. Kerr and I have also been focusing on the significance of metabolic oxidation balance and nutritional efficiency in pigs relative to feeding oxidized animal fats and vegetable oils. Our initial studies were funded by the National Pork Board and the Fats and Proteins Research Foundation.

Checkoff: What areas of research hold the most promise for improving overall nutritional efficiency? Why?

Shurson: Energy is the largest, most expensive component of swine diets. Availability and cost competitiveness of high energy (corn and fats and oils) ingredients is decreasing. Therefore, we need to use lower cost alternative ingredients that are often higher in fiber and lower in energy. Many of these high-fiber ingredients have not been evaluated extensively for their benefits and limitations in swine feeds. We don't understand fiber very well in swine nutrition. First of all, there are multiple ways being used to measure fiber in feeds and feed ingredients, and each measures a different group of complex carbohydrates that make up fiber (less digestible carbohydrates). Secondly, we need to get a better understanding of the positive and negative roles fiber plays relative to energy and nutrient utilization. Third, managing variability in energy and nutrient content and digestibility is critical for accuracy of feed formulation and optimizing diet nutritional efficiency. Byproduct ingredients are much more variable in nutrient content and digestibility than conventional ingredients like corn and soybean meal. We need to develop fast, inexpensive, and accurate "nutritional tools" to determine net energy and digestible nutrients in feed ingredients in order to manage this variability and obtain the highest value.

Section 1: DDGS – Determining Digestibility

The first step in better understanding efficiency of nutrient utilization is to determine the digestibility of the feedstuffs used in the diet. This section summarizes the research that was conducted relative to determining the digestibility of various co-products of the ethanol industry. To view a complete list of the projects funded through the Nutritional Efficiency Consortium as well as the full reports for these projects, visit www.pork.org/research.

Key Findings:

Gained a better understanding of the digestibility of nutrients in DDGS and other corn co-products

- Investigated the causes of the variability in the quality of DDGS
- Determined DE and ME values for DDGS various sources
- Determined the equations that can be used to accurately calculate NE
- Evaluated the digestibility of lipid and fiber in DDGS

Applications:

These findings allow producers and swine nutritionists to more accurately account for the feeding value of corn co-products in swine diets.

- Update existing databases with nutritional information about specific alternative feedstuffs
- Formulate diets more accurately to prevent over or under feeding of nutrients
- Utilize alternative feedstuffs as suitable replacements for traditional feedstuffs and thereby reduce the cost of the diet

(07-173) Critical review of literature on feeding bio-fuels co-products to pigs

The digestibility of nutrients in distillers co-products vary among sources. The variability is of the same magnitude as for other co-products. Heat damage to lysine often occurs, which results in a greater variation in the concentration of total and digestible lysine than for all other nutrients. It is, therefore, important that the concentration of lysine be measured before distillers co-products are included in diets fed to pigs. For corn DDGS, the average concentration of total lysine is approximately 0.78% and sources of corn DDGS with lysine concentrations below average also have concentrations of digestible lysine that is below average. Such qualities of corn DDGS should not be used in diets fed to pigs without extra fortification with crystalline lysine.

The inclusion of inorganic sources of phosphorus can be reduced in diets containing DDGS because the digestibility of phosphorus is greater in all fermented distillers co-products than in corn, but this is not the case for unfermented co-products. The concentration of starch is low in all distillers co-products and the concentration of fiber is relatively high in most co-products. The concentration of energy in the products is less variable than the digestibility of nutrients, but there is variation among the different co-products according to the procedure used to produce them.

If corn DDGS of average or above average quality is used, approximately 30% can be included in diets fed to lactating sows, weanling pigs, and growing-finishing pigs, whereas 50% can be included in diets fed to gestating sows. Inclusion of sorghum DDGS should be limited to 20% in weanling pig diets, but 30% may be included in diets fed to growing-finishing pigs. Corn HP-DDG may be included in diets fed to growing-finishing pigs in quantities sufficient to substitute all soybean meal, but there are no data on the inclusion of corn HP-DDG in diets fed to sows or weanling pigs. Corn germ can be included in diets fed to growing-finishing pigs in concentrations of at least 10%.

Carcass composition and palatability is not influenced by the inclusion of DDGS, HP-DDG, or corn germ in diets fed to growing-finishing pigs. However, belly firmness is reduced and fat iodine values are increased by the inclusion of DDGS and HP-DDG in these diets. It may therefore, be necessary to reduce the inclusion of these products in the diets fed during the final 3 to 4 weeks prior to slaughter.

All diets containing distillers co-products should be formulated in such a way that the concentration of crude protein is not greater than in traditional corn soybean meal diets. This requires the use of crystalline sources of amino acids to balance the amino acid profile of the diets. Glycerin, a co-product from the biodiesel industry, may be included in diets for weanling pigs by at least 6% and in diets for growing-finishing pigs by up to 15%. At these inclusion levels, no change in pig performance or carcass composition will be observed.

(09-119) Fate of lysine during the bioprocess of making DDGS

Among all the indispensable amino acids in DDGS, lysine is the most variable amino acid and has the lowest digestibility in pig feeding trials. The culprit was suggested to be heat damage that occurs during DDGS production. This study investigated the effects of corn-to-ethanol unit operation conditions on lysine quality in intermediates and DDGS. In order to better estimate the heat damage to lysine, the investigators measured furosine; a compound produced when lysine is damaged by heat. A total of eighty samples were analyzed and they include corn flour, slurry, mash, fermentation broth, whole stillage, thin stillage, syrup, wet cake, DDG and DDGS. What was learned from this study is summarized as follows:

1. High temperatures, long residence times and high glucose levels are the major factors causing heat damage to lysine during the making of DDGS.
2. With the lysine level in corn around 0.27% and the percentage of lysine in crude protein of corn around 3.0%, the DDGS produced in this study contained lysine levels ranging from 0.52% to 1.1% and the percentage of lysine in crude protein of corn ranged from 1.9% to 3.2%, due to the various extent of heat damage to lysine.
3. Furosine is not a naturally occurring compound in corn, but the furosine levels in DDGS in this study ranged from 0.03% to 0.22% due to the various extent of heat damage to lysine. The high end of the furosine levels in DDGS suggests that heat damage could lead to lysine digestibility as low as 70%.
4. The furosine to lysine ratio of DDGS can be a good indicator for heat damage to lysine. Based on this study, the DDGS with good quality lysine the percentage of furosine in lysine was lower than 10%, while the DDGS with heat damaged lysine was as high as 40%.
5. Color of DDGS is not a very good indicator for heat damage to lysine.

(09-142) Comprehensive evaluation of lysine digestibility in DDGS

Five assay methods for determining the lysine digestibility in DDGS were tested, including the measurement of color, the immobilized digestible enzyme assay (IDEA), the enzymatic pepsin-pancreatin procedure, acid detergent insoluble nitrogen (ADIN) measurement, and front face fluorescence method. The values for DDGS obtained from each procedure were compared with the standardized ileal digestibility (SID) of lysine of DDGS in swine diet obtained from a previous study. The highlights of this study were:

1. No linear correlation has been observed between the color of DDGS and the SID of lysine of DDGS, and no linear correlation has been observed between the IDEA value of DDGS and the SID of lysine of DDGS.
2. The in vitro enzymatic assay or ADIN did not predict in vivo standardized ileal digestibility of CP and Lys in DDGS fed to pigs.
3. Accurate SID Lys prediction models can be developed to provide good estimates within a defined data set but does not accurately predict SID Lys using data from samples not included in the model.

(07-143) Energy and amino acid digestibility of corn distillers syrup by-products in growing pigs

The purpose of this study was to determine the energy, amino acid, nitrogen and phosphorus digestibility of thin stillage, condensed distillers soluble, ground and intact syrup balls, and DDGS when fed to growing pigs. The highlights of this study were:

1. Amino acid digestibility of ground and intact syrup balls was equal to, or higher than that of DDGS, whereas digestibility of liquid condensed distillers solubles was lower than that of DDGS for total essential amino acids, but not for lysine.
2. Pulse dried thin stillage had the lowest amino acid digestibility, which was likely a result of heat damage during the pulse drying process. These results indicate that the presence of syrup balls does not decrease amino acid digestibility of DDGS and condensed distillers soluble has essential amino acid digestibility lower than DDGS.
3. The amount of digestible and metabolizable energy is relatively high and these ingredients are acceptable for use in growing swine diets.
4. Nitrogen digestibility is also relatively high compared to other by-product ingredients.
5. Phosphorus digestibility of all of these co-products is high and far exceeds phosphorus digestibility in corn and soybean meal.

In conclusion, feeding DDGS with ground or intact syrup balls has little impact on the nutritional value of DDGS for growing swine. The presence of syrup balls does not decrease amino acid digestibility of DDGS. However, formulating diets containing LCS requires accounting for lower amino acid digestibility since the LCS evaluated in this study has lower EAA digestibility than DDGS.

(07-172) Net energy of three sources of distillers dried grains with solubles fed to growing and finishing pigs

The DE and ME are energy systems that share important shortcomings: they systematically overvalue fibrous or high-protein feedstuffs and they systematically undervalue fats for use in swine diets. These deficiencies in measurement of dietary energy are very important to the economics of pig production and there is, therefore, an increasing interest in using a system based on NE of feed ingredients rather than DE or ME. It has been suggested that profits from pig production in North America would be improved by $2 to 3 per pig if diets were formulated based on a NE system rather than a DE or ME system. However, there are no NE values for co-products from the dry grind ethanol industry such as DDGS and high protein distillers dried grains with solubles (HP-DDG). The objective of this project was to measure NE values in two sources of DDGS and in HP-DDG. The two sources of DDGS were a conventional DDGS and a DDGS produced from uncooked corn. The NE values were measured in growing as well as in finishing pigs to test the hypothesis that finishing pigs are better able to digest the available nutrients in DDGS than are growing pigs. A summary of the key findings follows:

1. Results showed that for both growing and finishing pigs, growth performance were unaffected by dietary treatments.
2. In growing pigs, no differences were observed in energy retention, and the NE of the products tested was not different.
3. Finishing pigs fed the conventional DDGS diet had greater lipid gain than pigs fed DDGS from uncooked corn or the HP-DDG diet.
4. In finishing pigs the NE of conventional DDGS than the NE of DDGS from uncooked corn and HP-DDG
5. The average NE was greater in finishing pigs than in growing pigs.

DDGs Type	NE Growing Pigs (kcal/kg)	NE Finishing Pigs (kcal/kg)
Conventional	1,665	2,718
Uncooked corn	1,596	2,065
High Protein	1,783	2,291

(08-107) In vitro estimation and in vivo determination of metabolizable energy in corn co-products

Energy feeds contribute a significant expense to swine diets and constitutes more than 60% of pig production costs. Accurate energy values must be established for new corn co-products to provide nutritionists more options in generating nutritionally balanced swine diets. The twenty co-products evaluated in this study had unique nutrient profiles and resulted in a wide range of organic matter digestibility and apparent metabolizable energy values. The results of this project can be summarized as follows:

1. The in vitro organic matter digestibility ranged from 33.3 to 93.5% for corn bran and dried solubles, while ME ranged from 2,334 to 8,755 kcal/kg for corn gluten feed and corn oil, respectively.
2. Although laboratory analysis of organic matter digestibility was correlated ME in the animal, it did not improve the prediction of ME from ingredient analysis.
3. Stepwise regression resulted in the equation: ME, kcal/kg = (0.949 × gross energy) – (32.238 × total dietary fiber) – (40.175 × ash) which will provide a reliable estimate of ME in corn co-products commonly fed to growing swine.

(08-174) Development of equations to predict the metabolizable energy content of distillers dried grains with solubles (DDGS) samples from a wide variety of sources

In practice, the ME content of DDGS is generally estimated using prediction equations based on its chemical composition; however, published equations currently used by the industry give a range of ME values for the same sample of DDGS. Therefore, the objective of this study was to develop regression equations to predict the ME content of DDGS based on chemical composition. The study used DDGS samples obtained from 17 sources (Midwestern ethanol plants) that were chosen to represent the variation in nutrient content currently available to the industry. The highlights of this project can be summarized as follows:

1. There was considerable variation in the energy content and chemical composition of the 17 DDGS samples. Also, there were relatively large differences between the results of the chemical analysis for the two laboratories for a number of the chemical components.
2. The DE and ME values for the corn sample determined in the energy balance study were within the range of previously reported values for corn.
3. The DE content of the DDGS samples ranged from 3,663 to 4,107 kcal/kg DM and the ME content from 3,381 to 3,876 kcal/kg DM. The prediction equations developed in this study should, therefore, apply to DDGS samples from ethanol plants in the Midwest that are currently supplying product to the swine industry.
4. In general, correlations between chemical composition components and the DE and ME content of DDGS were relatively weak and, also, differed between the two laboratories. Equations to predict the ME of DDGS based on chemical components also differed between laboratories.
5. Equations based on proximate analysis components were relatively poor predictors of ME content but adding other components to the 4-variable equation based on proximate analysis components to create 6- or 7-variable equations improved the accuracy of prediction of the ME of DDGS.

This study clearly highlighted the large amount of variation present in the chemical composition and energy content of DGGS samples from different sources. In addition, equations were developed to predict the ME content of DDGS based on chemical composition. A critically important finding is that these equations differed between the two laboratories used for the chemical analysis. As in many situations, the choice of the most appropriate equation to use will be based on a balance between the accuracy of the equation compared to the costs of carrying out the chemical analyses.

(11-136) Validation of Digestible and Metabolizable Energy Prediction Equations, and Determination of Net Energy of Corn DDGS Sources Varying in Fat and Fiber Content in Growing Pigs

The final report for this project was not available at the time of publication.

The objectives of this project are to: 1) refine digestible and metabolizable energy (DE and ME, respectively) values for (DDGS) ranging in fat content from 5 to 14%; 2) validate DE and ME prediction equations determined for DDGS of varying fat content that are currently being determined in two funded projects, 3) determine the net energy (NE) content in these same DDGS sources, and 4) validate NE in a commercial setting.

(11-168) Energy and P-digestibility in bakery meal and corn co-products

The final report for this project was not available at the time of publication.

The objective of this research is to determine the digestibility of energy and phosphorus (without and with microbial phytase) in bakery meal and corn co-products and to compare these values to the digestibility of energy and P in corn and distillers dried grains with solubles (DDGS). At the conclusion of this research, values for the DE and ME and the digestibility of phosphorus without and with phytase will be available to the feed and swine industries. It will then be possible to formulate diets containing bakery meal, hominy feed, and other corn co-products based on values for digestible energy and nutrients.

(10-073) Effects of exogenous phytase on the apparent total tract digestibility of energy and phosphorus, and on the standardized total tract digestibility of P in corn, DDGS, HP DDG, and corn germ

The objective of this research was to measure the effects on energy and P digestibility of adding phytase to corn, DDGS, HP DDG, and corn germ at 0, 500, 1000, and 1500 FTU per kg of diet fed to growing pigs. It was a further objective to develop regression equations for the inclusion of phytase in each ingredient, which will allow users to calculate the digestibility of P in the 4 ingredients regardless of the level of phytase in the diet. A broken line analysis was also conducted to identify the level of phytase in each ingredient that maximizes P digestibility. Results of this research have considerable value to U.S. swine producers because it allows producers to optimize the use of distillers co-products and take advantage of the high digestibility of P in some of the co-products from the ethanol industry. A summary of the results is presented below:

1. This project provided data to the U.S. swine industry that allow feed companies and producers to optimize the use of phytase in diets containing corn and corn co-products. By optimizing the utilization of P, diet costs will be reduced, which will lower production costs of pigs, and thus, improve the competitiveness of US pork.
2. Results of this research also showed reduction in the excretion of P from animals, which will allow producers to apply more manure per acre and thus reduce the costs associated with manure applications.

Results of this research can be implemented immediately so the savings to pork producers can be obtained without delay and without requiring producers to invest in additional technology on their operations.

(11-097) Improving fiber digestibility in DDGS from ethanol production

The final report for this project was not available at the time of publication.

The objective of this project is to assess effects of pretreatment methods (chemical, enzymatic, and mechanical) on the digestibility of energy in DDGS. Combinations of different methods will also be investigated using in vitro models. The most promising 4 methods or combinations will be used in an in vivo experiment to determine if the improvements observed in vitro will also result in improvements in energy digestibility of DDGS when fed to pigs. The desired outcome of this project is to identify a simple, cost-effective procedure that may be used to process DDGS to enhance energy digestibility and thereby improve the nutritional value of DDGS when fed to pigs.

(07-170) Digestibility of dietary fiber from distillers co-products fed to growing pigs

The efficiency by which the pig will utilize the energy in DDGS is directly affected by the digestibility of dietary fiber. Measuring the digestibility of dietary fiber in DDGS is, therefore, the first step towards optimization of the utilization of energy from DDGS. There are, however, no data on the digestibility of dietary fiber in DDGS by growing pigs. Therefore, the objective of these experiments was to measure the digestibility of dietary fiber in DDGS by growing pigs and to measure the difference in fermentation capacity among different sources of DDGS.

1. Results show that the AID, ATTD, and fermentation of TDF among corn DDGS sources are different. The AID of TDF ranged between 12.6 and 38.2%, the ATTD of TDF ranged between 23.4 and 57.0%, and the fermentation of TDF ranged from 10.5 to 38.6%.
2. Those differences in digestibility and fermentation properties of the different sources of DDGS can explain the variation in digestibility of energy that has been previously reported. This suggests that the digestibility of dietary fiber in DDGS needs to be improved to increase the digestibility of energy.
3. The soluble dietary fiber is degraded and absorbed faster than the insoluble dietary fiber. The AID of SDF was 64.4% while the AID of IDF was only 20%. This indicates that sources of DDGS with greater concentration of SDF have a greater feeding value than sources with greater concentration of IDF. Also, processes that increase the concentration of SDF help in improving the utilization of dietary fiber by pigs.
4. Results also showed that there is no difference in AID or ATTD of TDF between DDGS produced from corn and DDGS produced from sorghum. These data also suggest that DDGS from the fuel ethanol and the DDGS from beverage production are similar in terms of digestibility of dietary fiber.

In conclusion, data from these experiments suggest that the digestibility and fermentation of the dietary fiber in DDGS is less than 50%. This low digestibility of fiber in DDGS is the reason why energy and DM digestibility is lower in DDGS than in corn. It is necessary, therefore, to identify factors that may increase the fermentation of dietary fiber in DDGS to increase the digestibility of energy from DDGS.

(09-020) Preparing for the inevitable increase in fiber content in practical pig diets

The objectives of this project were to 1) evaluate the best ways to characterize dietary fiber from corn co-products, 2) determine the site of digestion of dietary fiber in the pig to better understand its potential contribution to dietary energy and 30 evaluate the impact of the inclusion of dietary fiber from corn on growth performance and on the digestion and utilization of energy and nutrients in the diet. The highlights of the project are as follows:

1. The digestibility of fiber is greater in DDGS than in corn, indicating that fiber digestibility is improved by processing or fermentation at the ethanol plant. However, because of its components, fiber in corn co-products is more resistant to microbial fermentation.
2. The digestibility of dietary fiber is also variable among corn co-products, which in turn may affect the digestibility of energy and nutrients differently.
3. Results also indicated that increasing the fiber level in the diet with corn fiber, as may be the case of DDGS, decrease the digestibility of energy, fiber and nutrients of the diet, including lysine and most of the AA.
4. Fat proved to be a mechanism to compensate for the reduction in energy supply when fiber is increased. The relatively high content of fat in DDGS mitigates the negative effects of increased fiber in the diet due to DDGS inclusion. Production of lower fat varieties of DDGS, however, may decrease the digestibility of energy and nutrients in the diet even further and as a consequence, the dietary net energy.

(08-115) Ileal and total tract apparent and true digestibility of fat in distillers dried grains with solubles and other corn oil products fed to growing pigs

The specific objective of this project was to measure the true ileal digestibility and the true total tract digestibility of fat in extracted corn oil, intact corn oil from high oil corn, DDGS, HP- DDG, and corn germ and to compare these values to the digestibility of fat in soybean oil. Here are the highlights of this project:

1. The digestibility of fat was greater in extracted corn oil and full fat soybeans than in the other ingredients. However, HP- DDG and DDGS had greater digestibility of fat than high oil corn and corn germ, which indicates that the fermentation process in the ethanol plants increases fat digestibility.
2. It is concluded that the digestibility of fat varies greatly among feed ingredients. As a result, it is not possible to predict the impact of a specific feed ingredient on quality of pork fat just by measuring the concentration of fat in that ingredient. Instead, it is necessary to formulate diets based on the digestible concentration of fat in the diets.

For the first time, this research provides digestibility values for fat in distillers co-products and other feed ingredients. Using these data, it is now possible to formulate diets fed to growing and finishing pigs based on concentrations of digestible fat, which in turn allows producers to predict the effects of a specific diet on the quality of the fat in pigs fed that diet.

Section 2: DDGS – Impact on Growth and Carcass

Traditionally, corn and soybean meal have been the primary components in swine diets because of their cost and availability. Today, commodity market conditions have led producers to seek low-cost alternatives to these traditional feedstuffs. However, the effect these alternative feedstuffs have on animal performance, carcass characteristics, pork quality, and ultimately, consumer eating experience, needs to be determined. To view a complete list of the projects funded through the Nutritional Efficiency Consortium, as well as the full reports for these projects, visit www.pork.org/research.

Key Findings:

Gained a better understanding of the impact of DDGS on pig growth performance and pork quality

- Determined amount of DDGS that can be incorporated in swine diets with minimal effect of growth
- Investigated the duration of withdrawl of DDGS from late finishing diets
- Established methods of mitigating the effect of DDGS on pork fat quality

Applications:

The results of these research projects allow producers and swine nutritionists to optimize the amount of DDGS to be added in swine diets

- Conduct cost benefit analysis to determine the impact of including DDGS at a specific concentration
- Determine the amount of additional dietary fat to add to mitigate the effect of DDGS on pig performance and pork quality

(07-152) Assessment of corn distillers dried grains with solubles (DDGS) from ethanol production on performance and carcass quality of growing-finishing swine

This was a large experiment involving multiple experiment stations with the objective being to assess the effects of feeding high levels of DDGS on performance of growing-finishing pigs from 71 to 265 lbs. body weight and on carcass and belly firmness. Corn-soybean meal diets containing 0, 15, 30 or 45% DDGS were fed to growing-finishing pigs in three phases. The following is a summary of the results of this experiment:

1. Growth rate over the entire experimental period was reduced slightly (2.9% linear decrease) in pigs fed the two higher levels of DDGS.
2. Daily feed intake and efficiency of feed utilization were not significantly affected by DDGS inclusion
3. Carcass yield was not affected by level of DDGS fed.
4. Backfat and loin eye area decreased slightly as did loin eye area in pigs fed the two higher levels of DDGS.
5. Belly flex measurements were significantly affected by increasing levels of DDGS in the diet.
6. The iodine values of the inner layer of backfat increased from 61.6 in the controls to 82.5 in that of pigs fed the highest level of DDGS.

In summary, these results show that rather high levels of DDGS (up to 45% DDGS in the diet) can be fed to growing-finishing pigs without having much of an effect on growth performance or carcass leanness. However, these high levels do result in a higher proportion of polyunsaturated fatty acids in the backfat, higher iodine values in the backfat, and softer, more flexible bellies.

(07-144) Influence of rapid introduction and removal of dietary DDGS on pig performance and carcass characteristics

There is very little direct evidence of the pig's response to frequent inclusion and removal of DDGS from the diet. If there are no changes in pig performance when switching between DDGS and non-DDGS diets, more pork producers may include DDGS in diets when it is economical, knowing that switching between DDGS and non-DDGS diets will not result in any reduction in pig performance. This project was conducted to determine the effects of switching between corn-soybean meal and corn-soybean meal-DDGS diets on pig performance and carcass quality of finishing pigs. The results of this project are summarized as follows:

1. Dietary treatments had no effect on average daily weight gain.
2. With the exception of feed efficiency, growth performance was not different among pigs fed the control diet continuously, the 20% DDGS continuously or the 20% DDGS and control diets in an alternating pattern.
3. Pigs fed the 20% DDGS diet continuously were not as efficient as those fed the same diet alternated with the control diet.
4. Pigs switched on and off a 40% DDGS diet were lighter at the end of the 70-day study and produced a lighter carcass than pigs assigned to the other treatments because they tended to consume less feed.
5. Dressing percentage and carcass fat-free lean percentage were not affected by dietary treatments.

Results of this study suggest that the frequent inclusion and removal of 20% DDGS from diets for finishing pigs will not adversely affect pig performance or carcass characteristics. It appears that alternating 40% DDGS in and out of the diet may reduce feed intake and hot carcass weight of finishing pigs.

(09-044) Effects of rapid introduction and removal of high and low digestibility corn distillers dried grains from the diet, and dietary inclusion rates on growth performance and carcass characteristics of growing-finishing pigs

Trait	CON	Lo-CON	Hi-CON	Lo	Hi	Hi-Lo
ADG, lb	2.01	2.01	2.04	1.88	1.94	1.93
ADFI, lb	5.89	5.95	6.08	5.61	5.88	5.87
F:G	2.93	2.96	2.98	2.98	3.05	3.05
Ultrasound BF, in	0.84	0.78	0.81	0.75	0.71	0.78
Ultrasound LMA, in^2	6.93	6.92	7.02	6.26	6.62	6.29
Hot carcass wt, lbs[1]	206.0	203.8	208.3	192.5	197.3	195.3
Carcass lean, %[1]	51.8	52.1	52.1	51.3	52.3	50.8
Dressing %[1]	76.2	75.8	76.0	74.7	75.1	74.6

Due to inevitable price fluctuations of feed ingredients, pork producers and nutritionists are frequently seeking low cost feed ingredients capable of reducing overall feed expense without compromising pig performance and carcass quality. No data have been published regarding the effects of feeding grower-finisher diets containing 40% or more DDGS on growth performance and carcass quality. Therefore, the objective of this project was to determine whether relatively high dietary levels of high digestible AA DDGS can be fed throughout the grower-finisher phase to achieve acceptable performance and carcass quality. An additional objective was to determine if intermittent inclusion of DDGS of different estimated AA digestibilities into diets can be achieved without affecting feed intake and carcass composition. Dietary treatments consisted of: 1) a corn-soybean meal control (CON); 2) a corn-soybean meal diet containing 40% low AA digestibility DDGS (Lo); 3) a corn-soybean meal diet containing 40% high AA digestibility DDGS (Hi); 4) Lo and CON diets alternated throughout the trial (Lo-CON); 5) Hi and CON diets alternated throughout the trial (Hi-CON); and 6) a diet alternating between Hi and Lo (Hi-Lo). The highlights of this study are summarized in the below:

1. Pigs continuously fed a 40% low digestible AA DDGS based diet formulated on a Standardized Ileal

Digestible (SID) AA basis, experience lower ADG, reduced ADFI, lighter HCW and smaller LMA than pigs continuously consuming a corn-soybean meal based diet.
2. The use of a high digestible AA DDGS source may be able to diminish the negative responses incurred in growth performance and carcass characteristics when feeding DDGS at a 40% level.
3. The periodic inclusion and removal of 40% DDGS from the diets of finishing pigs did not adversely affect growth performance or carcass characteristics regardless of the AA digestibility of DDGS being fed.

(07-167) Evaluation of choice white grease and beef tallow to improve pork quality when pigs are fed distillers dried grains

The objective of this project was to determine the impact of a 26 day withdrawal of 20% DDGS prior to slaughter in combination with beef tallow or choice white grease would do to grow-finish pig performance, carcass traits and bacon quality. The results of this project can be summarized as follows:

1. Pigs that stayed on the 20% DDGS diet throughout the GF period were nearly 9 lbs. lighter and carcass weight was 8.5 lbs. lighter with a reduction in carcass yield of 1.7% than the Corn-SBM control pigs at the end of the grow-finish period.
2. Pigs that switched from the 20% DDGS diet to being fed the Control plus 5% BT diet the last 26 days prior to slaughter had 18% greater ADG than pigs fed the 20% DDGS diet during this phase.
3. Pigs fed the Control plus 5% beef tallow and the Control plus 5% choice white grease diets had 20% better feed efficiency (G:F) than the pigs fed the 20% DDGS diet during these final 4 weeks premarket.
4. The 26-day preslaughter removal of the DDGS and supplementing with either 5% fat sources in the corn-soy diet during this preslaughter period restored carcass weights to that of the corn-soy control pigs.
5. Belly and backfat iodine values increased 8-10 units when pigs were fed 20% DDGS and the 26-day withdrawal of DDGS only partially recovered fat iodine values by 1-4 units depending on supplemental fat source inclusion, with the greatest response due to switching to a corn-soy plus5% beef tallow preslaughter diet.

(08-015) Assessment of the effects of diets containing DDGS with supplemental tallow on fat digestibility, growth performance, carcass and fat quality in growing-finishing pigs

Adding a saturated fat source (e.g. tallow) to grower-finisher diets containing a high level (30%) of DDGS may alleviate the negative effects of DDGS on pork fat firmness. Therefore, the objective of this study was to assess the effects of fat source (tallow and corn oil from DDGS) independently, and in combination, on growth performance, carcass quality, and pork fat quality and apparent ileal fatty acid digestibility. The highlights of the data from this project are at right:

Feeding a combination diet of 5% tallow and 30% DDGS did not negatively impact growth performance. However, pork fat quality is not improved with the addition of tallow (saturated fat source) to diets containing DDGS (unsaturated fat source). Furthermore, the addition of tallow to DDGS diets does not improve belly firmness, even though it does reduce IV in belly fat, but not in backfat.

	Tallow		DDGS	
	0%	5%	30%	30%
Trait	Control	Tallow	DDGS	DDGS+Tallow
Overall ADG, lb	2.23	2.30	2.23	2.22
Overall ADFI, lb	6.09	5.71	6.08	5.40
Overall F:G	2.74	2.49	2.73	2.43
Hot Carcass Weight, lb	195.29	201.97	194.77	197.03
Carcass yield, %	78.77	79.55	78.34	79.35
Belly flop angle, ^{0}	125.8	115.3	72.6	63.1
Belly Iodine Value	59.0	64.2	71.2	67.9
Backfat Iodine Value	56.7	61.9	68.3	71.8

(09-109) Methods of Restoring Carcass Firmness and Other Post-Harvest Traits in Finishing Pigs Fed a High Level of Distillers Dried Grains with Solubles (DDGS)

The amount of DDGS that can be used in swine feeds without causing reduced performance of pigs or soft bellies that are discriminated against by pork processors is not known. This project had three objectives. First was to determine if withdrawal of a high level (45%) of DDGS from the diet during the final 2, 4, or 6 weeks of the finishing period. Second was to determine if the addition of a harder, more saturated fat (tallow) to a diet containing DDGS would prevent the softer bellies and high iodine numbers that occur when high levels of DDGS are fed. Third was to further evaluate the effects of dietary inclusion of DDGS on the processing characteristics of cured bellies, physical characteristics of sliced bacon, and eating quality of bacon and loin chops. Here are the highlights of this project:

1. This study clearly shows that some of the belly firmness problems and elevated iodine values in carcass fat that are associated with the feeding of high levels of DDGS in the diet can be overcome by withdrawing the DDGS from the diet during the final 4 to 6 weeks of the finishing period.
2. A 4-week withdrawal produced acceptable iodine values with a mean of backfat and belly fat IV of approximately 70.
3. The addition of a hard fat such as beef tallow to the diet, however, was unsuccessful as a means of improving belly firmness and elevated iodine values of pigs fed DDGS at high dietary levels.
4. Under the conditions of this study, the softer bellies, increased polyunsaturated fatty acids, and higher iodine values did not negatively impact bacon processing or eating quality of bacon or loin chops in pigs fed a high level of DDGS.

(08-094) Characteristics and eating quality of bacon and sausage from finishing pigs fed medium and high levels of distillers dried grains with solubles (DDGS) from ethanol production

The objective of this project was to assess the effects of feeding high levels of corn DDGS on performance of growing-finishing pigs from 76 to 265 lbs. body weight, and on carcass and belly firmness, fatty acid composition of the fat, slicing efficiency of cured bacon, and eating quality of bacon slices, bratwurst sausage, and loin chops. This project can be summarized as follows:

1. Rather high levels of DDGS (up to 45% DDGS in the diet) can be fed to growing-finishing pigs without having much of an effect on growth rate; however, the amount of feed required per unit of gain was increased with increasing amounts of DDGS in the diet.
2. Carcass leanness was not greatly affected by level of DDGS; however, the high levels of DDGS in the diet resulted in higher proportions of unsaturated fatty acids in the body fat, higher iodine values in the backfat and belly fat, and softer, more flexible bellies.
3. These responses were linearly relative to the amount of DDGS in the diet.
4. Regardless of the changes in fat composition, the slicing efficiency of cured bacon slabs, quality measures of fresh sliced bacon, and eating quality of bacon, bratwurst sausage, and loin chops did not seem to be negatively affected by feeding 30 to 45% DDGS to growing-finishing pigs.

(07-148) Influence of dietary DDGS and glycerol on pork loin and bacon quality

The goals of this study were to determine the impact of 0 and 20% DDGS and the inclusion of glycerol at levels of 0, 2.5, and 5% in grow-finishing rations on loin and bacon quality, and determine the relationship between belly firmness and slicing yield for commercially produced bacon. The results of this project can be summarized as follows:

1. Feeding DDGS and glycerol in combination or singularly at the levels tested did not practically impact loin quality traits.
2. Feeding 20% DDGS did decrease belly firmness, although, not to a degree that would affect any processing characteristics.
3. Furthermore, our results suggest that the addition of 20% DDGS to finishing swine diets will not be detrimental to sensory components in bacon.
4. Feeding glycerol at 2.5 and 5% of the diet did not positively or negatively affect any fresh belly or bacon characteristic that would increase or decrease the profitability of bacon production.
5. Finally, adding glycerol to the diet 2.5 and 5.0% did not change fatty acid composition of loin intramuscular fat or belly fat.

(08-093) Sulfur concentration in distiller's dried grains with soluble (DDGS) and its impact on palatability and pig performance

This study provided a comprehensive investigation on whether or not increasing concentrations of sulfur in DDGS can impact the palatability and performance of weanling and growing-finishing pigs. The study also provided in-depth information on various chemical forms of sulfur in DDGS and the cause for increasing sulfur levels in DDGS. This project can be summarized as follows:

1. Pigs fed the control diet (corn and soybean meal) gained more weight and had greater feed efficiency compared with those fed diets containing DDGS. However, there were no differences in performance between pigs fed a diet containing low or high levels of sulfur and it is, therefore, unlikely that the sulfur in DDGS is reducing the palatability of the diet.
2. Producers, therefore, do not need to worry about the levels of sulfur in DDGS because pigs do not reduce performance when fed diets containing DDGS with a high sulfur level compared with pigs fed a diet containing DDGS with a low sulfur level.
3. The major source of sulfur in DDGS is the inorganic sulfur or sulfate and that originates from sulfur that is added during production of ethanol indicating that the corn to ethanol production process is the main factor responsible for the relatively high sulfur levels in some sources of DDGS.

(10-002) Evaluation of lipid oxidation levels in DDGS sources and impact of feeding (with or without antioxidants) on swine health, performance, and metabolic oxidation

One of the objectives of this study was to evaluate the effects of feeding a diet containing DDGS with a high content of oxidized lipids and sulfur on pig growth performance and metabolic oxidation status, and to determine if any of the negative effects could be overcome by increasing dietary level of vitamin E. Additionally, this project determined whether the high sulfur content in DDGS could protect against lipid peroxidation in pigs fed DDGS diets. The highlights of this project are as follows:

1. Total sulfur content was higher in DDGS diets than control.
2. Dietary inclusion of 30% DDGS improved apparent total tract digestibility of sulfur, as well as sulfur absorbed and retained compared to control.
3. Although pigs were fed highly oxidized DDGS in this study, serum indicators of oxidative stress were similar between DDGS and CON treatments.
4. Serum vitamin E increased by feeding DDGS diets compared to control.
5. In addition, pigs fed DDGS diets had higher concentrations of sulfur-containing amino acids, particularly methionine and taurine in serum of fed pigs, and a higher concentration of taurine in serum of fasted pigs compared with those fed control diets.
6. Liver glutathione concentration was higher in pigs fed DDGS diets than control and dietary inclusion of DDGS and α-tocopherol increased serum enzyme activity of glutathione peroxidase.

In conclusion, elevated concentrations of sulfur-containing antioxidants (methionine, taurine, glutathione) may protect pigs against oxidative stress when feeding highly oxidized DDGS. Therefore, increasing levels of vitamin E in diets containing DDGS with high oxidized lipid content may not be necessary to protect pigs from metabolic oxidation stress.

Section 3: Nutritional Efficiency of the Breeding Herd

While the growing and finishing period accounts for the vast majority of feed cost in pork production, improving nutritional efficiency of the breeding herd can make a substantial contribution toward improving profitability. To view a complete list of the projects funded through the Nutritional Efficiency Consortium as well as the full reports for these projects, visit www.pork.org/research.

Key Findings:

Investigated the role of the breeding herd in improving nutritional efficiency

- Determined the effect of feeding DDGS to sows in two different types of sow housing on sow performance
- Determined the effect of feeding DDGS to sows on pork fat quality
- Improved the efficiency by which amino acids are passed from the mother to the offspring during lactation

Applications:

The results from these studies allow producers and nutritionists to make feeding management decisions to improve nutritional efficiency in the breeding herd

- Consider the impact of feeding DDGS in sow rations on sow and litter performance
- Alter sow diets to utilize amino acids effectively for improve piglet growth

(08-004) Interactive effects of distillers dried grains with solubles (DDGS) and housing system on sow performance and longevity

The objectives of this study were to: 1) determine the long-term effects of feeding DDGS to sows on reproductive performance over three reproductive cycles; 2) determine if feeding DDGS during gestation and lactation will improve longevity and welfare of sows in two different gestation housing systems; and 3) quantify the increase in fecal and urinary output resulting from feeding DDGS to reproducing sows. The results of this project can be summarized as follows:

1. Sows fed DDGS or control began the experiment with equal body weight. However, at the end of the first reproductive cycle, DDGS-fed sows were 4 kg lighter than control-fed sows and at the end of the second reproductive cycle they were 8 kg lighter than control-fed sows. These differences in body weight suggest that young sows were less able to derive energy and nutrients for body growth from DDGS diets than older sows.
2. Live born litter size was 0.5 pigs less for DDGS-fed compared with control-fed sows which translated into 0.4 fewer pigs per litter at weaning. The smaller litters nursing DDGS-fed sows gained less weight than litters nursing control-fed sows. The smaller weight gain of litters from DDGS sows was most evident during the first reproductive cycle lending support to the idea that young sows had more difficulty digesting diets containing DDGS.
3. Sows housed in pens during gestation and fed DDGS supported the lowest litter weight gain compared with sows assigned to the remaining three treatments.
4. The percentage of sows completing three parities in this experiment (control/stall: 71.8%; control/pen: 56.0%; DDGS/stall: 66.0%; DDGS/pen: 55.5%) was not statistically different among diet and housing treatments.
5. Over the entire experiment, feeding DDGS reduced the total number of pigs weaned by 0.8 while housing

sows in pens of 50 sows during gestation reduced total number of pigs weaned by 2.1.
6. Sows fed DDGS were more aggressive in pens as they were involved in longer and more aggressive fights with pen-mates compared with control-fed sows. In contrast, DDGS-fed sows in stalls spent more time resting and less time engaged in stereotypic behaviors than sows assigned to CON which suggests sows were more satiated and content.

In conclusion, it appears that feeding high levels of DDGS to reproducing sows may result in marginal depressions in production of weaned pigs. These reductions are more likely in young sows (parity 0 and 1) compared with older sows. In this study, gestation housing system had a larger effect on reproductive performance than did diet.

(09-014) Evaluation of the pork quality of sows fed diets with different levels of distillers dried grains

The overarching goal of this work was to determine if DDGS at 0, 15 or 30% inclusion during gestation and/or lactation altered sow performance and/or final products, namely bratwurst and breakfast links.

1. There appeared to be little effect on sow performance (piglet litter size, litter weight gain or litter weight gain per day) and/or piglet numbers regardless of diet fed.
2. There were no differences noted in sow feed intake during gestation and/or lactation between any of the different treatment combinations offered.
3. There were no differences in the relative amount of carcass fat accumulated or deposited during the entire study. It was anticipated that the relative amount of unsaturated fatty acids would be higher in the sows fed DDGS, but differences in IV was small.
4. Across both bratwurst and breakfast links there was relatively little difference in preference of the actual product, i.e., eating experience wise.

(09-148) The influence of increasing dietary intake of omega-3 fatty acid concentration on postpartum hypophagia and energy output in the milk via alterations in lipolytic activity and insulin sensitivity of the adipose tissue

The overall objective of this project was to improve the reproductive and productive functions of high producing sows by determining how altering the dietary fatty acid profile of sow diets would affect her whole body metabolism and her ability to provide nutrients and energy to her offspring by looking at milk energy output, piglet growth rate, sow feed intake and the role of leptin on feed intake and the responsiveness of sow adipose tissue to be mobilized when required. The diets were formulated to have a constant total fat concentration (5% crude fat), but varied in the ratio of n-6 to n-3 FA's. The treatment groups consisted of a control (tallow), 3 diets with plant oil based n-6:n-3 ratios (10:1, 5:1, and 1:1) as well as a 5:1 fish oil diet. The results of this project can be highlighted as follows:

1. Reducing the n-6:n-3 fatty acid ratio in sow diets had a wide range of effects on the reproductive performances of sows. A ratio of 5:1 increased piglet performance and sow feed intake. A plant-based ratio of 1:1, and a fish-based ratio of 5:1 lead to reductions in feed intake.
2. Metabolic adaptations of the sows were measured in the 10:1 and 1:1 fed groups and results of this study show that sows fed at 1:1 ratio diet appeared to be in a state of negative energy balance relative to the 10:1 pigs throughout early lactation.
3. There were no differences between diets on piglet performance, and thus on estimated milk energy and nutrient outputs. With the exception of the fish-based diet, there were no major effects on piglet growth rates, indicating that sows will compensate for changes in feed intake through body fat mobilization, ensuring that their offspring are provided with an adequate supply of energy and nutrients for growth. We

observed optimal sow performance when diets with a n-6:n-3 fatty acids ratio of 5:1 were fed throughout gestation. This can be accomplished in a typical corn, soybean meal diet, or a wheat- barley based diet with added corn oil by adding about 0.5 % flaxseed oil.

(08-113) Regulation of amino acid transport efficiency by the porcine mammary gland

The objectives of this study were to 1) quantify the expression of genes that encode for milk and Lys transporter proteins and assess whether these genes are correlated; 2) measure the efficiency of Lys utilization for milk production in response to feeding an optimum amino acid balance in a reduced crude protein diet; 3) quantify the expression of genes that encode for milk and Lys transporter proteins in response to feeding an optimum amino acid balance in a reduced CP diet; 4) assess whether change in Lys utilization efficiency for milk production is related to changes in the expression of genes encoding for Lys transporter proteins. The following is a summary of the results of this project:

1. The study demonstrated that feeding an optimum balance of amino acids achieved through crystalline amino acid inclusion improves the efficiency of Lys utilization (mammary extraction efficiency) and maintains lactation performance if provided in a reduced CP diet. These findings will allow the development of effective nutritional tools that can be immediately implemented to positively impact both lactation performance and the environment.
2. The study demonstrated that there are two Lys transporter genes that are related to genes encoding for mammary synthesized milk proteins, which in the longer term may be targeted to further understand how amino acid transporters regulate milk production.
3. The results of the study demonstrated that changes in expression of genes encoding for Lys transporter proteins were not related to Lys extraction efficiency, indicating that other or additional mechanisms regulate Lys transport; for instance, in this study, increased Lys extraction efficiency by the mammary gland was related to lower circulating levels of the branched-chain amino acids, pointing to competitive inhibition mechanism between amino acids for uptake into the mammary gland.

In conclusion, the results of this project show that improvement in Lys utilization for milk production may be achieved by decreasing the levels of non-limiting amino acids, such as the branched-chain amino acids, in order to decrease the competition between Lys and those amino acids for mammary uptake.

Section 4: Genetics of Nutritional Efficiency

Much of the progress that has been made toward improving nutritional efficiency can be attributed to application of genetic selection for this trait by individual swine breeders as well as commercial genetics companies. Though much of the early, rapid progress may be considered by some to be the genetic "low-hanging fruit", there is little evidence indicating the biologic limit of nutritional efficiency has been reached. To view a complete list of the projects funded through the Nutritional Efficiency Consortium as well as the full reports for these projects, visit www.pork.org/research.

Key Findings:

Gained a better understanding of the underlying biological differences resulting in improved nutritional efficiency

- Differences in body composition account have a substantial impact on nutritional efficiency
- Selecting for certain behavioral characteristics can have an impact on nutritional efficiency

Applications:

The results of these studies allow producers and nutritionists to determine the impact genetic selection has on improving nutritional efficiency.

- Change breeding and selection programs to take advantage of genetics that result in reduced feed usage while maintaining average daily gain

(07-161) Identification of biological factors responsible for differences in feed efficiency between selection lines for residual feed intake

Residual feed intake is a unique measure of feed efficiency because it represents true differences in the ability of pigs to use feed energy for the metabolic processes of maintenance and growth. The objective of this research project was to identify the main biological factors that contribute to differences in RFI. This research capitalized on a unique line of Yorkshire pigs that has been selected for reduced RFI for 5 generations and requires 7% less feed for the same rate of growth and backfat than the randomly bred control line. The results of this project can be summarized as follows:

1. Pigs from the more efficient line demonstrated different feeding behavior because they ate faster and less often but did not differ much in other behaviors that were studied. However, they tended to be slightly less active compared to the non-select line.
2. They were more efficient under both ad libitum and restricted feeding and required less feed to maintain a constant weight
3. They tended to have lower internal organ weights, a lower fat content of the carcass, but had greater dressing percentage and better carcass composition with limited effects on selected measures of meat quality such as pH and water holding capacity,
4. They had decreased carcass lipid content and postmortem protein degradation and had physiological parameters that indicated less protein turnover and energy expenditure in muscle.

In conclusion, although a substantial part of differences in feed efficiency as measured by RFI are related to differences in body composition, part of the differences appear related to pen and feeding behavior and to lower maintenance requirements and energy expenditures. Selection for RFI does not have major negative effects on meat quality.

(11-124) Determining the biological and metabolic differences between slow growing and fast growing transitioning pigs raised in commercial conditions

The final report for this project was not available at the time of publication.

The objective of this project is to determine the metabolic basis for poor weaned-pig transition (10th percentile ADG) compared to better-transitioning contemporaries (70th percentile ADG) by identifying changes in metabolic pathways that are correlated with, and may control, differences in post-weaning success using transcriptional profiling and gene expression.

(09-051) Effect of selection for feed efficiency during the growing period on sow feed efficiency and reproductive performance

The objective of this experiment was to evaluate sow reproductive performance in the unique selection lines for RFI. The summary of this research is provided as follows:

1. After 6 generations, the select line had two more piglets farrowed per litter yet only one more piglet born alive. This was due to the select line having one more stillborn per litter.
2. There was no difference in number of mummies between the two lines, although the trend was for the select line to have 0.1 more mummies per litter.
3. There was no difference between the lines in the number of piglets weaned by sow, thus the select line lost one more piglet from birth to weaning.
4. The select line had greater litter weights at birth, even after adjusting for number born. The select piglets kept this weight advantage through to weaning and also grew faster during the lactation period. However, this increased performance in terms of piglets was at a cost to the sow; although there was no difference in body weight or composition (as estimated using ultrasonic backfat) at the start of lactation, sows from the select line lost more weight during lactation.
5. In generation 6, the select line consumed less feed than the control line. Generation 6 was also the first generation that resulted from selecting the control line for increased RFI.

In conclusion, selection for RFI has positively affected piglet numbers and pre-weaning growth but has negatively affected sow body condition change during lactation.

Section 5: Processing of Feedstuffs

Processing feedstuffs for use in swine diets can greatly improve nutritional efficiency through a variety of mechanisms. To view a complete list of the projects funded through the Nutritional Efficiency Consortium as well as the full reports for these projects, visit www.pork.org/research.

Key Findings:

Gained a better understanding of the impact feedstuff processing and inclusion of enzymes has on nutrient utilization

- Reducing particle size of DDGS improves nutrient digestibility
- Pelleting diets reduces problems associated with feed flow-ability and improves energy utilization
- When nutritionally adequate diets are fed, inclusion of enzymes has little effect on pig performance

Applications:

The results of these projects allow producers and nutritionist to determine the optimal particle size to be targeted when manufacturing swine diets.

- Make adjustments for diet manufacturing specifications
- Determine if the addition of enzymes will improve pig performance and nutrient utilization

(11-170) Effects of reducing the particle size of corn fed to growing pigs

The final report for this project was not available at the time of publication.

The objective of this project is to measure the effects of different particle sizes of corn on energy and nutrient digestibility and performance of growing pigs. This research will have considerable value to US swine producers because it will allow producers to implement technologies that improve profits without making any additional investments in their operations because producers and feed companies can change grinding size without investing in new technology. It is believed that the increased value of reducing the particle size of corn grain can be 11 to 21 USD per ton of feed produced, but there are no good data to exactly identify the grinding size that is needed to achieve this saving. This research, however, will fill this gap and identify the particle size that optimizes amino acid, phosphorus, and energy digestibility of corn.

(09-037) Impact of DDGS particle size on DM, energy, nitrogen, and phosphorus digestibility in diets for growing pigs

The objectives of this study were to determine DE and ME content, and evaluate the effect of different particle sizes of DDGS at a 30% dietary inclusion rate in corn diets on DM, energy, nitrogen, and phosphorus digestibility and flow-ability in growing pigs. Single sourced DDGS was processed through a hammer mill to achieve of mean particle sizes of 818, 595, and 308 µm. The results of this project are highlighted as follows:

1. Adding 30% DDGS to a corn based diet reduces flow-ability, and grinding DDGS to 308 µm further reduces flow-ability compared to 594 and 818 µm particle sizes.
2. Adding 30% DDGS to a corn based diets decreases dry matter digestibility, which will result in an increase in fecal excretion and manure production.
3. For each 25 micron decrease in DDGS particle size from 818 microns to 308 microns, the ME contribution of DDGS to the diet is increased by 13.7 kcal/kg DM.
4. Pelleting DDGS diets would eliminate the problem of flow-ability and the extra energy value from using finely ground DDGS can be realized.
5. If diets must fed in meal form, flow-ability may be acceptable if the DDGS particle size is greater than 600 µm, and some of the improved ME value of DDGS from a reduced particle size can be obtained.
6. Based on our results, DDGS particle size does not affect protein and phosphorus digestibility, so there is no additional economic or feeding value due to particle size on these economically important nutrients.

(11-169) Re-evaluating moderate to severe feed processes in light of high ingredient prices and the increasing use of fibrous feedstuffs

The final report for this project was not available at the time of publication.

The overriding objective of this project is to improve the industry-wide lack of knowledge of how corn particle size and complete diet feed processing are influenced by high co-product in diets for nursery and finishing pigs to reduce feed cost for swine producers. In order to accomplish this overall objective, the specific objectives researched will be to 1) quantify relative costs associated with different degrees of feed processing (i.e., grinding, expanding, and pelleting), 2) evaluate the effects of a broad range of moderate to severe feed processing on the growth performance of nursery pigs (25 to 50 lb BW) and 3) evaluate the effects of fine grinding and pelleting within a commercial setting on the growth performance and carcass characteristics of commercial finishing pigs.

(08-111) Critical evaluation of commercially available enzymes, and processing on nutrient digestibility of swine diets containing DDGS

Application of enzymes in an effort to improve nutrient digestibility of plant-based feed ingredients for swine and poultry has been studied for decades. Essentially, an enzyme(s) must match the target substrate(s) in a feedstuff which have been shown to have a negative impact on nutrient digestibility or voluntary feed intake. As such, there may need to be a 'cocktail' of enzymes to effectively breakdown the complex matrixes of fibrous carbohydrate structures. The current experiment involved the evaluation of 10 commercially available feed additives (enzymes, yeast, and probiotics) in nursery and finisher pigs fed diets containing 30% DDGS, each over a 5 week period. The results of this experiment can be summarized as follows

1. Commercially available enzyme/additive products have variable (both positive and/or negative) effects on nutrient digestibility coefficients, but none of these products were effective in improving starter or finishing pig growth performance when fed nutritionally adequate corn-soy diets containing 30% DDGS.

Section 6: Additional Research

In addition to the work pertaining to DDGS, this consortium has funded a variety of other projects ranging from the use of soybean hulls to development of strategies to genetic selection. Regardless, all are designed to improve our knowledge and understanding of how to improve nutritional efficiency. To view a complete list of the projects funded through the Nutritional Efficiency Consortium as well as the full reports for these projects, visit www.pork.org/research.

Key Findings:

Improved our understanding of how dietary components interact to affect nutritional efficiency

- Determined the role that fiber plays in nutritional efficiency
- Investigated how lipid oxidation affects pig growth and performance
- Evaluated the effect of glycerol on pig performance
- Determined the effect of aflatoxin on gene expression in the liver

Applications:

Producers and nutritionists will be able to use this information as they incorporate alternative feedstuffs in swine diets

- Update existing feedstuffs databases to reflect improved knowledge of the nutritional value of various alternative feedstuffs
- Develop least-cost diets utilizing alternative feedstuffs without affecting pig performance
- Determine the biologic consequence of feeding feed contaminated to aflatoxin

(11-139) Reducing feed cost through improved knowledge of using soybean hulls in modern commercial swine nursery and finishing diets

The final report for this project was not available at the time of publication.

The overriding objective is to improve the industry-wide lack of knowledge in utilizing finely ground soybean hulls for nursery and grow-finish pigs to reduce feed cost for swine producers. In order to accomplish this overall objective, the specific objectives researched will be: 1) under commercial nursery conditions (15 to 50 lbs. BW) determine the impact of increasing finely ground soybean hulls up to 12% in corn-soybean meal and corn-soybean meal-DDGS based diets on growth and overall economics and 2) under commercial growing-finishing conditions (70 to 280 lbs. BW) determine the impact of increasing finely ground soybean hulls up to 12% in corn-soybean meal-DDGS based diets on growth, carcass traits and overall economics.

(07-165) Evaluation of crude glycerin in swine

The objective of the proposed research was to determine the variation in ME content of crude glycerin samples from a several biodiesel production facilities using different feedstock sources (soybean oil, animal fat, and used restaurant grease). The results of this project are summarized in the following way:

1. The gross energy (GE) of the crude glycerin samples ranged from 3,173 to 6,021 kcal/kg while the determined ME ranged from 2,535 to 5,206 kcal/kg, each being a reflection of the concentration of glycerol, methanol, and free fatty acids in the crude glycerin.
2. Prediction of each crude glycerin's ME based upon the crude glycerin's composition was poor.
3. Prediction of each crude glycerin's GE based upon the crude glycerin's composition high [GE kcal/kg as-is basis = -306 + (46.65 × % glycerin) + (54.31 × % methanol) + (101.83 × % fatty acids)].
4. Because the relationship between GE and ME was similar between all crude glycerin samples, averaging 85.4%, ME could be accurately predicted based upon the predicted GE and the average ME:GE of 85.4%.

In conclusion, data from this project shows that the concentration of glycerin, fatty acids, and methanol affect the GE and ME of crude glycerin, and because crude glycerin is easily digested and metabolized, it can be used as a viable source of energy in growing pigs.

(07-151) Utilizing glycerol in swine diets: I. Feed manufacturing considerations and nutritional strategies to reduce dietary costs

Little is known about glycerol's nutritional value for swine or how it impacts feed quality and feed production. The objective of this project was to evaluate the effects of glycerol on feed characteristics, the pelleting process, and nursery pig growth performance. The results of this project are summarized below:

1. As was expected, roller mill ground grain had a lower angle of repose compared to grain ground with a hammermill, indicating less feed bridging would occur with roller mill ground grain. Glycerol or a 50:50 soy oil/glycerol blend improved the flowability of the hammermill ground grain, but did not influence the flowability of the roller mill ground corn. Suggesting that the addition of glycerol to a meal diet containing hammermill ground corn and spray-dried whey tends to improve flowability.
2. Increasing the level of crude glycerol in the diet up to 9% improved pellet quality and durability.
3. Glycerol tended to reduce the electrical energy consumption, thus improving pelleting efficiency.
4. Pigs fed increasing levels crude glycerol had an increase in weight gain, but no differences were observed in the efficiency of gain.
5. Adding glycerol to diets prior to pelleting tends to improve pellet quality and decreases energy cost. However, it does not appear glycerol can replace lactose in weanling pig diets.

(10-013) Evaluation of lipid source and oxidation level on digestible and metabolizable energy concentration, and the impact of lipid oxidation on intestinal barrier function

The objective of this project was to gain a better understanding of methods to assess quality and feeding value of feed fats and oils. The results of this study are summarized as follows:

1. There was no effect of lipid peroxidation (slow or rapid peroxidation) DE or ME content or on apparent total tract digestibility of dry matter, gross energy, ether extract, nitrogen, carbon, and sulfur when fed to nursery pigs.
2. Feeding rapidly oxidized lipids to nursery pigs for 28 days tended to reduce ADFI and ADG compared to pigs fed non-oxidized lipids suggesting that lipid peroxidation can negatively impact pig growth performance.
3. Feeding slow and rapid oxidized lipids to nursery pigs increased plasma measures of oxidative stress but had no effect on intestinal barrier function as measured by the lactoluse-mannitol protocol utilized in the current study.
4. Feeding thermally oxidized lipids altered lipid metabolism.

In conclusion, the data suggested that feeding thermally-peroxidized lipids to young pigs has little influence on gut barrier function or serum immunity parameters, but may decrease liver triglyceride concentrations, impair metabolic oxidative status, and reduce growth performance, especially if fed lipids containing high concentration of polyunsaturated fatty acids.

(11-126) Impact of mitochondrially targeted novel antioxidant on pig feed efficiency

The final report for this project was not available at the time of publication.

Inefficiency in mitochondrial biogenesis and increased electron leakage resulting in reactive oxygen species production, oxidative stress, and inflammation may be a primary mediator of reduced feed efficiency in growing pigs. Our overall objective is to evaluate the effect of a novel antioxidant (MitoTBHQ) that is known to readily penetrate mitochondria for minimization of reactive oxygen species (ROS) production on mitochondrial function and animal feed efficiency. Our hypothesis is that decreasing the oxidative stress within the mitochondria of pigs with MitoTBHQ will improve feed efficiency and thus growth efficiency of pigs. We will test the derivatized antioxidant (MitoTBHQ) with the nonderivatized tertiary butylhydroquinone (TBHQ) antioxidant (common food additive) and with the control (no added antioxidant) in pigs selected for high residual feed intake (low feed efficiency).

(08-075) Effects of dietary aflatoxin on hepatic gene expression in swine

Aflatoxins, especially aflatoxin B1 (AFB1), can be high in dried distillers grains with solubles (DDGS) when concentrated during the ethanol production process. The objectives of this study were to determine the effects of AFB1 on 1) the health, performance, and serum profiles and 2) the hepatic gene expression of growing barrows. Diets were formulated to contain 0 (CON), 250 ppb AFB1 (LOW), or 500 ppb AFB1 (HIGH) for 7, 28, or 70 d. Feed intake was measured daily, and pigs were weighed and blood samples collected weekly. The results of this project are highlighted as follows:

1. Average feed intake was less in HIGH barrows than in CON barrows from wk 5 to 10, and was less in LOW barrows than in CON barrows in wk 5 and again from wk 8 to 10.
2. Lower ADG was observed in HIGH barrows than in CON barrows in wk 8 and 10.
3. No statistical differences in liver health as assessed by histological grading were observed among the 70 d treatment groups.
4. These results demonstrate that performance and blood parameters in young growing barrows are affected by consumption of an aflatoxin-contaminated diet, especially when the concentration of aflatoxin is high (≥ 500 ppb); however, even lower concentrations (250 ppb) are detrimental to performance when administered for a more chronic period.
5. Changes in the expression of genes involved in a variety of functions related to cellular stress and toxicity responses, such as apoptosis, regulation of cell growth and proliferation, and mRNA processing, are differentially regulated in response to AFB1.

(08-182) Development of a soy allergenicity model in swine

A problem that seriously impacts both the swine and soybean industries is the adverse reactions of young piglets to soy based rations. Two approaches were initiated to address these problems. One was to breed swine populations from which neonatal piglets can be obtained that either lack or exhibit immune-mediated hypersensitivity upon exposure to soy-based rations. The second was to develop soybeans whose compositions differed markedly with respect to known seed allergens, and then to use these proteins to ascertain whether these differences could be perceived when the two groups of neonatal piglets were exposed to them. To facilitate the detection of an immune-mediated response, an assay was developed to measure the appearance of soy-specific antibodies in serum from piglets challenged with soy protein. Two conclusions can be drawn based upon preliminary evaluation of piglets from the two breeding populations.

1. The adverse reaction of early weaned pigs to soy rations may be reduced or eliminated through swine breeding
2. It is possible to produce swine populations that are superior to existing animal models for the study of legume allergy.

(11-127) Development of a practical net energy system (productive energy) that allows for the capture of ingredient cost savings expected from NE systems but focuses equally on maintaining pig performance

The final report for this project was not available at the time of publication.

The objective of this proposal is to validate the concept of productive energy (PE), an energy system based on the INRA (French) net energy system but "corrected" for application in an American context. It makes no sense for the American industry to "re-invent the wheel" on energy systems; our proposal represents a practical, lower-cost strategy to take a net energy system developed in Europe to satisfy European needs and evolve it to function effectively in the United States, where the pork industry structure and operation are slightly different. Simply stated, we want to determine if we can take the INRA NE system of ingredient values and equations and adopt them to an American context and do so at a low cost. The approach is practical, strategic and progressive; it represents a fully integrated partnership between a commercial entity (Hanor) and an academic entity (ISU).

The specific objectives are to: 1) determine the degree of error that occurs when applying the INRA NE values to diets formulated and fed under typical commercial conditions in the U.S. and 2) determine if adjustment of the French NE values can be undertaken in growth studies using feed conversion as the primary, most accurate and lowest cost outcome criterion.

If successful, then the logical next step in subsequent years would be to undertake a series of titrations to define the PE value of specific ingredients as well as a series of titrations to develop PE prediction equations based on nutrient composition of ingredients and feeds.

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