2012

Swine Profitability Conference

Sponsored by
Department of Animal Sciences and Industry
K-State Research and Extension
Kansas State University, Manhattan

SWINE PROFITABILITY CONFERENCE

Sponsored by

Department of Animal Sciences and Industry and
K-State Research and Extension Service of
KANSAS STATE UNIVERSITY

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Kansas Pork Association
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Tuesday, February 28, 2012
Forum Hall, K-State Union

SWINE PROFITABILITY CONFERENCE

KSU Forum Hall
K-State Union
Tuesday, February 28, 2012

Program Agenda

Morning Program

9:15 a.m.	Registration
9:30 a.m.	Jack and Pat Anderson Lecture in Swine Health Management: **Lessons from Large Production Systems that Can Help the Competitiveness of Land-Based Producers** *Dr. Gene Nemechek, Pfizer Animal Health*
10:30 a.m.	**What Have I Done to Make My Land-Based System Successful** *Kent Condray, Clifton, KS*
11:15 a.m.	**Short and Long-Term Price Outlook: How Will Consumer Preferences on the Welfare Front Impact Your Operation?** *Dr. Glynn Tonsor, Kansas State University*
Noon	**Lunch**

Afternoon Program

1:15 p.m.	**How to Keep Your Swine Operation off YouTube** *Cindy Cunningham, National Pork Board*
2:00 p.m.	**Humor for the Heart of Agriculture** Damian Mason, Humorist
3:00 p.m.	**Adjourn**

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February 28, 2012

Jack and Pat Anderson Lecture in Swine Health Management:

“Lessons from Large Production Systems that can help the Competitiveness of Land-Based Producers”

by

Dr. Gene Nemechek
Pfizer Animal Health
Wilson, NC

Jack and Pat Anderson Lecture in Swine Health Management:
"Lessons from Large Production Systems that can help the Competitiveness of Land-Based Producers"

Gene Nemechek, DVM
Pfizer Animal Health, Wilson, NC

The large pork production systems have increased in size, controlling a much higher percentage of the total pigs produced in the US. What does that mean for the independent land-based pork producers? Can the land based pork producers remain competitive, sustainable, and viable in today's pork industry? I will attempt to share some of the observations of the large production systems that I have made over the past 30 years. Hopefully, some of these observations will give the land based producers in the audience some areas to think about and maybe evaluate and incorporate into their pork production business.

Pork Production as a Stand Alone Business

Pork Production: A Systems Approach

The large production systems early on developed production standards that were used as guidelines for day after day production practices. These standards gave structure and consistency to the productions practices which outlined how things were to be done on the farms. These standards were written down and used for training of new and existing employees. These guidelines outlined everything from feeding animals, breeding practices, building environmental management, heath management, farrowing house management, pig processing, record keeping, and grow finishing management. This systems approach accomplished a uniformity of production practices across numerous operations and employees, and produced a uniform consistent end product. These standards required a constant regular update process as well to keep up with improvement in technology and production practices. The written standards for production allowed for structured process for training of new employees across the entire production system.

Pork Production: Method for Measuring and Monitoring Production Parameters

As the large production systems increased in size and complexity, it became obvious that they required a record system to measure production and financial parameters. Without a method for measurement, business decisions for improvement were difficult. Lenders began to require production and financial records to support lending decisions. The competiveness and cyclical nature of pork production pressured production systems to adopt record systems to measure the production parameters of their business.

Record systems were developed or purchased to monitor on farm production: pigs per sow per year, individual sow productivity, farrowing rates, weaning performance, death losses, growth and feed conversions. To complement the production records, financial record systems were developed to measure the financial impact of production practices. These record systems were used to measure farm performance differences between units and managers, as well as the production cost differences between farms. Producers must use the records, not just generate them. Pick out the few key parameters and focus on those areas.

The next step involving the production records and production cost moved forward with large production systems interest in comparing how they performed against other large production systems. That demand for comparison allowed for the evolvement of independent record keeping companies that provided a confidential records comparison service that allowed for benchmarking. The benchmarking/records services allowed for large production systems to evaluate their production and cost and revenue parameters when measured against similar production systems. This benchmarking can measure and compare information such as sow productivity, grow-finish performance, caloric conversion and cost, veterinary and health cost, transportation cost, and financial returns between individual production units and between entire production systems.

Pork Production: A People Business

The large production systems realized that pork production was a business that required an investment in human capital. Efficient pork production required a continuous source of quality, talented, educated, experienced, and motivated employees. The pork industry is really a people business that just happens to raise pigs. People make the difference in a production system's success. The large production systems realized early on that they needed to hire human resource consultants to hire and train the employees needed to staff the production units and associated business entities. Company employees are continuously trained on new production practices, animal welfare standards, animal handling, company code of conduct, and harassment issues.

Pork Production: Turn Feed Ingredients into High Quality Protein

Large production systems typically are not involved in raising and producing the grains for their pig diets. Feed costs are still the highest cost in pork production, regardless of the size of the operation. The large production systems are constantly analyzing the nutritional aspect of their business in order to control feed cost, maximize nutritional efficiency, and utilize all types of available ingredients. Large production systems have either hired swine nutritionist or consultants to continuously make ration adjustments based of ingredient cost, availability, and nutrient specifications. In addition to the nutritionist's involvement, most large production systems, in an effort to control cost, have also hired consultants to provide ingredient purchasing advice. The Kansas State University Swine Nutrition Group leads the country in providing the swine nutrition guidelines for the US pork industry.

Pork Production: Herd Health

Large production systems have not been immune to the detrimental effects of swine diseases that adversely impact performance. The large productions systems realized that they needed access to updated information on disease control, testing procedures, disease prevention, and disease treatment. Most large production systems have either hired staff veterinarians or they keep swine veterinarians on retainer for advice on disease control. In many cases the swine veterinarians are the first line of information for not only disease and herd health, but also overall farm management as well. Veterinarians must continue to be educated on the continuous technology and management changes that are occurring in today's pork industry.

Pork Production: Genetics

The large production systems realized early on the importance and advantage of utilizing high producing female lines crossed to high quality terminal sires to produce a uniform, high carcass quality, fast growing, and feed efficient market hog. While genetics companies have made their product lines available to all size customers, volume purchases and the establishment of genetic nucleus herds along with production system boar studs have allowed large systems to lower their overall genetics cost. The genetic options to produce a top quality market hog are available to all size producers but the health considerations must be a top consideration when making a genetic decision. The length of time required for generation turnover makes it imperative to make the right genetic decision as well.

Pork Production: Purchasing

Volume purchasing and discounts have become a way to reduce the cost of production for the large production systems. The large production systems obviously buy more volume: health products, vaccines, feed ingredients, equipment, and supplies. The volume pricing used by many vendors has allowed the large production systems to use it as a way to reduce their cost of production. Many smaller producers and veterinarians have joined together to form buying groups to also take advantage of the volume pricing. The opportunity to use hedging and the futures markets for forward pricing is not limited only to the large producers, but it has been used by many of the large producers to limit risk. Many large production systems have full time staff totally focused on controlling input costs. My observations have been that these experts do not always make the right decisions.

Pork Production: Marketing

The large production systems used their production volume to their advantage at a time when packers paid premiums to producers who could supply increased volume of market hogs. As packers began to buy based on carcass quality, volume pricing became less of a factor. Today pork producers, regardless of size, can still negotiate with packers to provide top quality market hogs. The biggest opportunity that all pork producers have today to maximize their revenue is to sell their hogs in the correct matrix weight range for the packer to whom they market. I will leave the issue of futures pricing of the markets hogs to someone more qualified.

Pork Production: Areas of Opportunity

The following are some additional production practices that many large production systems have implemented to improve performance, increase revenue, and to reduce production and financial risk.

- Replacement gilt production and grow-out systems that minimize disease risk, maximize performance, standardize genetic performance, and reduce overall genetics costs.

- Production management teams that are separated based on production type: genetic, breeding/farrowing, nursery, grow-finish, boar stud. The specialized production focus generally improves production performance throughout the production system.

- Three site production: separation of production age groups and all in/all out flow of nursery and grow –finish. Strategic location of production sites based on the potential for reduction of area disease exposure can reduce health risk and improve production.

- Vaccination crews that are responsible for vaccinating all the weekly production flows.

- Market hog sorting and load out crews that are responsible the marketing of the hogs.

- Truck washes with TADD systems that are production system specific to improve biosecurity: truck washes separated for sow and wean pig production, nursery, finishing, and genetics.

- Environmental management teams responsible for nutrient management.

Pork Production: Responsible Pork Production

The National Pork Board and the National Pork Producers Council have implemented and promoted the **We Care Initiative**: Pork Producer's Commitment to Doing What's Right!

1. Produce Safe Food
2. Protect and Promote Animal Well-Being
3. Ensure Practices to Protect Public Health
4. Safeguard Natural Resources in All of Our Practices
5. Provide a Work Environment That is Safe and Consistent With Our Other Ethical Principles
6. Contribute to a Better Quality of Life in Our Communities

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SWINE PROFITABILITY CONFERENCE

February 28, 2012

"What Have I Done to Make My Land-Based System Successful"

by

Kent Condray
Pork Producer
Clifton, KS

What Have I Done to Make My Land-Based System Successful

Kent Condray
Pork Producer, Clifton, KS

INTRODUCTION

Jim approached me last summer at a meeting we were both attending about me being the next producer speaker for the profitability conference, I thought he was joking and didn't take him seriously. He kept bugging me all day and by the end of the day I realized he was serious. Serious as a heart attack which I may have before today is over with. Obviously he had run out of choices for speakers.

I was honored but no way could I stand in front of producers and tell my story, which isn't much different than any other producer here. But here goes.

HISTORY OF THE HOG OPERATION

From the middle 1950s to early 70s my father bought up to 300 weaned steers in the fall and he would background them in the winter and sell them in the spring to a feedlot or finish them out. The last year we had cattle was in 1973.

Starting in the fall of 1968, with my Dad and Brother Scott, who was a freshman in high school, started on a FFA project that turned in to my lifelong career! I was in the 7th grade and we started with 15 SPF gilts. We used what we had available, old cattle corrals for pens and barn lean to for a shed. We put farrowing stalls in the other side of barn to farrow in. We sold the gilts through Farmland's F1 gilt program for a few years. I graduated from High School in 1974 and went two years to Beloit Vo-Tech in Production Ag.

We continued to raise hogs, and in 1970 we built three open front sheds to gestate sows and feed hogs in. They were built with 10 to 12' high side walls with the thought if the hogs didn't work out they could be used to store machinery, hay or cattle. In 1971, we built a farrowing house with a solid concrete floor, and in 1974 built a Cargill floor. We were running around 125 to 150 sows: Breeding and Gestating Sows in dirt lots, farrowing in stalls on a solid concrete floor; finishing hogs on a Cargill floor or in dirt lots. This system was very labor intense.

When my brother graduated from K-State in 1976 he entered law school at Washburn, and wasn't coming back to the farm and exited the hog enterprise. That same year I graduated from Vo-Tech and returned to the farm fulltime. I ran the hog operation and helped with the grain side of the farm. I wanted to expand the hog operation with user friendly, less labor intense buildings. My father wanted to slow down but thought pigs would be a good way to market the farm's grain. He agreed to co-sign a loan for me with PCA, now Farm Credit, to expand the hog operation.

In 1979, my father exited the hog operation and I expanded to 280 sows. I built a breeding-gestation barn, farrowing house with 4-12 crate rooms and an 8 room nursery. I populated the farm with York-Duroc gilts from Fred Germann, and in 1980 we converted the old farrowing house to a grower barn, and built a 600 head MOF (modified open front) finisher barn. In 1983, we built another 600 MOF with the old Cargill floor and I was finally able to finish all our hogs on concrete.

All feed was made with a tractor and grinder mixer. I had two employees, life was good. Hogs were profitable. I paid down debt and bought a few farms. In 1992, we built another 300 sow farrow to finish farm three-fourths of a mile north of the home farm. We raised F1 gilts for Craig Good with a rapidly changing industry and with most farms switching to hi-brid gilts from breeding stock companies. Our F-1 gilt program didn't last as long as we would have liked it to. We were making feed for both farms with a portable grinder mixer. Running two 300 sow farms, and with the home farm needing updated, in 1998 we made the decision to convert N Farm to SEW farm, converted finisher to gestation barn, and built more farrowing rooms, increased to 1000 sows, and converted the home farm to a wean finish farm. From 1997-2006, one-half mile east of the home farm we built two 2,000 head nurseries, 180,000 bushel grain storage, and shop-office and feed mill. And from 1997-2006, one-half mile south of nursery farm built four 2,000 head finisher barns. In 2005, we doubled our sow capacity to 2,000 sows by adding another gestating barn and more farrowing rooms. As we have expanded, we have always been short on nursery and finishing capacity and currently we are transporting pigs to Iowa to feed. In 2011, we constructed four 1,200 head wean to finish barns, four miles north west of the feed mill. With this expansion we should be able to feed all of our pigs close to home.

In the past during expansions we usually employed 4 to 6 construction workers to pour concrete; frame buildings, build gates, and install equipment. Our barns didn't go up as fast as if we contracted them out as a turnkey project. We build as a Pay as you (go) Standard. These barns we finished last spring we subbed out the concrete work and also the framing. We built all the gates and installed the equipment.

HOW I INCORPORATE FAMILY, EMPLOYEES AND NEIGHBORS

FAMILY

In 1989 I got a new boss when I married Marian Charbonneau from Concordia; we lived near my parents in the country north west of Clifton. Marian was the manager of a card and gift store in Concordia. In 2005, she closed the store and Marian was a stay at home wife and mother and has in the last few years started working in our office with bookkeeping and record keeping in the finishing end, and also helping run errands as needed.

We have three daughters, our oldest Sarah graduated from high school in 2009, and is now a senior at Fort Hays State University, and was accepted into the nursing program in the fall of 2010. Sarah loved to go with me when walking finishing barns. She was 4 and loved to check the pigs and by the time she was 7 she was helping sort and load fats. Sarah has worked in several different aspects of our farming operation, from helping when she was 8 move tractors from field to field (which her mom didn't know about until she was 10); she helped with concrete and framing new buildings, and also helped during summer vacation in the sow unit. Dr. Henry is still holding out hope that she will come to her senses and stop nursing school and come to KSU to be a veterinarian.

Our middle daughter, Laura, was born 17 weeks premature and graduated in May of 2011. She is now a freshman at CCCC majoring in Elementary Education. Laura is legally blind but really doesn't let that get in her way. She has also helped sort and load. Her first job was watering down the fats once they were loaded. She helps with sow records and says she has been promoted to the front office.

Our youngest daughter Andrea is a junior at Clifton-Clyde High School and has not really figured out what she plans to do after high school but it will have something to do with fashion or cosmetology or as our older girls say living at home with her parents.

She does not like to get her hands dirty, Laura tells the story of being gone to camp and Andrea was to do her job while she was gone, which was watering the pigs down in the semi once they were loaded. One very hot summer night, Andrea decided to spray the sky, and not the pigs. She was fired by Laura when she got home.

So it is not very likely they will return to carry on the farm operation, but time will tell.

My first employee, Randy Jackson, started in 1979 and in April will have worked for me for 33 years. He is more than an employee; he is family and currently is the sow farm site manager. His dad runs our honey wagon, mows around the farm and is 83 years old and his mom was the babysitter for our girls, their adopted grandparents. Unfortunately, in October Phyllis passed away and was 79.

Employees, as I've said Randy Jackson has worked for me for almost 33 years and has been involved in all of our growth. We also have several loyal employees.

Doug DeRusseau has been my nursery supervisor for 8 years; Bob Leduc has worked for me since 2004. He loves working with animals but when his brother in law offered him a job at the local brick plant he gave it a try of 3 days and called to see if he could have his old job back. I told him okay, when can you start Monday. He told me "Well actually I told them yesterday I wasn't coming back so I can start tomorrow, Thursday." He was gone 3 days.

My office manager Tammy Elsasser has worked for me for 6 years and keeps everything all bookkeeping, payroll sow records and oversees the feed mill.

I had been putting an ad in the local newspapers for employees to work in all aspects of the farm, in the finishers, sow unit and building construction. Many times we ran ads and no qualified people applied. The last time we placed an ad we got no inquires at all.

We became aware of a program called World Wide Farmers Exchange; they find young adults in other countries that are willing to come to the United States on a work Visa to stay 1 to 1.5 years then return home.

Our first experience came in December of 2007, a couple from the Ukraine was already in the states and the farm they had been placed at was not working out. So they would be coming. Well, it came to an abrupt end when the farmer had them leave earlier; they were dropped off at a hotel and driven to our farm on New Year's Eve 2007. Their house was not ready, because we thought we had more time but we pulled it together and by the end of the day they had a roof over their heads and turned out to be exceptional workers. They applied for an extension on their visa and were given 6 more months so they would go home in the spring of 2009.

During that time we applied for and had another couple come from the Ukraine and that couple stayed for only one year. Because of high unemployment in this country visa extensions weren't being granted. They went home and they have in November returned to our farm under a new program for one year. The entire time they were home they worked on getting back over here.

Every employee we have had through this program has not worked out, in which case they are sent back home. My wife is like their mother and we are in turn their family. If they are sick she takes them to the doctor. Recently one of our (kids) fell and broke his arm which caused him to not work for 5 weeks. We continued to provide housing for him while he was off work.

This is like the Foreign Exchange student program for high school kids, these young people want to work and learn, and they most generally are here to earn money to take back to help family at home. One of our employees Max is married and his wife and small son are at home. He talks to them on Skype to keep in touch.

We have learned a lot about their country and we try to teach them about life in the USA, when we have family dinners they come, they go to our 4th of July celebration, Thanksgiving and Christmas. They also are invited to graduations and some birthday parties.

When we take them to the airport to send them back to their country we tell them until we see you again, because we are close to them and have plans in the future to visit their country and have them show us around.

We also have had very good luck with workers from Mexico; they speak very little English but are very willing to learn and want to have a better life for their families.

At this time we have 2 employees from the Ukraine and 8 from Mexico, kind of like the United Nations, we are the minority.

NEIGHBORS

I have several good neighbors. This is just one example: in May of 2010 a wind storm took down power lines, tipped over pivot irrigation systems, and damaged many buildings in the neighborhood. Early the next morning when I finished loading hogs I got in my pickup. I looked at my cell phone and had 2 missed calls (I leave my phone in pickup when loading to keep from losing it) from neighbors wanting to know if I needed help with building damage. We were lucky; we had some minor roof damage, lost power to all farms and had 4 center pivots destroyed and 2 with damage. Both of those neighbors also had damage but were concerned about the livestock.

I have always been grain deficient and always needed to feed more grain than I produce. We produce around one-half of our feed grain, and purchase the rest from neighbors. We take delivery for some at harvest, and also have neighbor deliver corn and milo throughout the year.

HOW I CAN USE LAND BASE TO MAKE MY OPERATION SUCCESSFUL

When I started farming I didn’t have a written business plan (and still don’t). I reinvested income back into the operation where I felt it would be the most beneficial to the farm at the time. We have around 900 irrigated acres with a crop rotation 1/3 acres planted to soybeans and 2/3 acres planted to corn annually and 2,100 dry land acres planted 1/3 acres to each crop wheat, grain sorghum and soybeans. I have all cropland custom farmed with no-till amounts to planting, spraying and harvesting. We hire an agronomist to take soil samples of all fields annually to use as a guide for fertilizer recommendations (also required for our Nutrient Management Plan approved by KDHE). He also scouts fields for weed and insect pressure every week during the growing season and also checks soil moisture on irrigated fields so we know when to irrigate. Hog manure is a great way to add nutrients to the soil. Most of our soils are high clay and hog manure seems to improve the productivity better than commercial fertilizer along with no-till practices.

Raising feed grains helps average income between livestock and grain prices. The farms I have bought have been paid for with income from hogs. In the past hogs have added value to grain in more years than not. Going forward with the export and ethanol demand for feed grains and soybeans, input cost are going to be higher. But the hog price will adjust for higher input costs in time. Until then grains will subsidize the hog operation.

The environment we do business in is always changing so we must change.

I really am not good at risk management. I am not disciplined enough, there are times I do ok other times I am terrible. There are so many variables and also basis swings. I at times forward price SBM from a processor and also at times buy corn ahead. If I can't buy enough cash corn ahead, I use futures or options for price protection. It is very hard to beat an average if marketing and buying inputs on a weekly basis.

MY FUTURE IN THE INDUSTRY

I don't spend too much time remembering the past; you must look forward and plan for the future.

It really does not look like any of my children will return to the farm. I'm 55 years old; I need to start planning an exit strategy, lease or transfer ownership in the future. I enjoy raising pigs, working with employees and allied industry people -extension, consulting vets and sales rep. etc. Kansas has a land grant university in KSU with excellent swine animal science dept. and Veterinary School. Kansas is a great place to raise pigs.

As long as this industry has adequate price discovery and packers need hogs there should be a place in this industry for efficient independent producers.

High feed cost due to demand for corn and soybeans for export and ethanol production are going to be an issue in the future. This industry will adjust and the hog corn ratio will become favorable again.

In closing, it's not what you make in this world - it's what you give back.

SWINE PROFITABILITY CONFERENCE

February 28, 2012

"Short and Long-Term Price Outlook: How Will Consumer Preferences on the Welfare Front Impact Your Operation?"

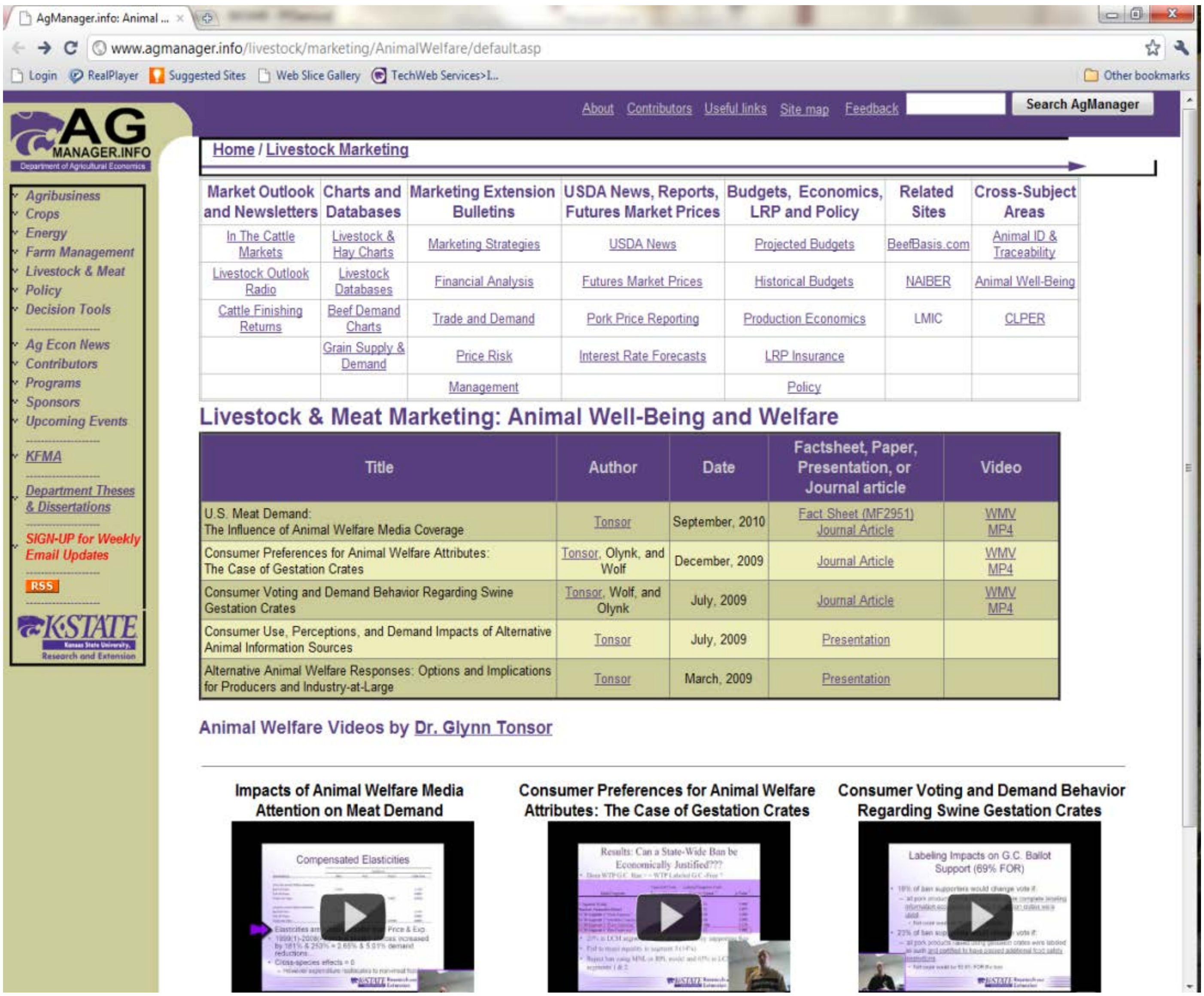
by

Dr. Glynn Tonsor
Kansas State University

Short and Long-Term Price Outlook: How Will Consumer Preferences on the Welfare Front Impact Your Operation?

Dr. Glynn Tonsor
Kansas State University

Additional material available to producers as discussed in Dr. Tonsor's presentation is available at http://www.agmanager.info/livestock/marketing/AnimalWelfare/default.asp



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SWINE PROFITABILITY CONFERENCE

February 28, 2012

"How to Keep Your Swine Operation off YouTube"

by

Cindy Cunningham
National Pork Board

How to Keep Your Swine Operation Off YouTube

Cindy Cunningham
National Pork Board

Today's Session

- Climate of watchdogs
- Could it happen on your farm?
- The best defense is a great offense
- What tools are available?
- Telling your story your way

DOING WHAT'S RIGHT. pork checkoff

Busy Day On The Farm

- Up & outside---coffee in hand
- Weather & markets---good
- Everything organized & working
- Cell phone rings
  - "Hi, I'm with ___, and we have damning evidence of animal abuse on your farm. I need a response from you in 10 minutes or we will call in the media."

DOING WHAT'S RIGHT. pork checkoff

Your First Thought…

- ?!#@?*&$%^^&!!
- Are you kidding me?
- Why me?
- I'm a good person
- We do things right on our farm
- What gives them the right to come in here and tell me how to run my farm?

We Care — Doing What's Right. Pork Checkoff.

Your Next Thought…

- How can I get control of this
  - before it gets out of hand?
- Where do I turn for help?
- Is there really something wrong going on
  - on my farm?
- How would they find out, if I don't even know?

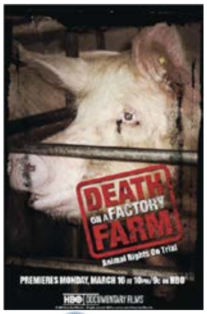
We Care — Doing What's Right. Pork Checkoff.

Understanding The Opposition

- Who are they?
  - Well funded
  - Strategic thinkers
- Why do they care?
  - Passionate about their cause
- What tactics do they employee?
  - No rules when it comes to their cause
- When will they stop?
  - When the money train runs dry…

We Care — Doing What's Right. Pork Checkoff.

Highly Visible & Graphic Campaigns



DOING WHAT'S RIGHT.

Death on a Factory Farm---HBO

DOING WHAT'S RIGHT.

Could It Happen On Your Farm?

DOING WHAT'S RIGHT.

Take a Look at Your Farm?

- What procedures are in place on your farm to assure you are not the next victim of a micro-camera?
  - Hiring
  - Training
  - Day-to-day production practices
  - On-farm personnel issues
  - Employee attitudes toward animals

DOING WHAT'S RIGHT.

Could You See This Device?

Ultra Mini Pencil Eraser Sized Color Pinhole Video Camera With TinyTek Pocket DVR

The world's smallest pinhole micro video camera that's so small, it has to be manufactured under optical magnification with the world's smallest pocket DVR (digital video recorder) with screen in a complete covert video recording kit! MSRP: $795.00 Your Cost Only $449.95

DOING WHAT'S RIGHT.

Looking For the Camera Vs. Doing The Right Thing

- Wouldn't you rather assure you are doing the right thing!
  - PQA Plus®
  - TQA®
  - We Care Responsible Pork Initiative
  - Ethical Principles

DOING WHAT'S RIGHT.

Ethical Principles

- Produce safe food
- Protect and promote animal well-being
- Ensure practices to protect public health
- Safeguard natural resources in all of our practices
- Provide a work environment that is safe and consistent with our other ethical principles
- Contribute to a better quality of life in our communities

Demonstrating To Our Customers

The "WOW" Test

- Can all of your production practices pass the consumer "WOW" test?
  - Euthanasia
  - Castration
  - Tails
  - Housing
  - Transport
  - Weaning

Two Sides To The Equation

- Assure daily production practices done correctly at the farm-level
- Work as industry to address those practices that raise questions

DOING WHAT'S RIGHT.

Your Staff--Hiring

- Not just filling boots
- Impacts bottom-line more ways than one
- And impacts each others attitudes
  - Do they like animals?
  - Are they abusive/disrespectful to others—may translate to pigs?
  - *Would you want them representing you or your farm? Because they are!*

DOING WHAT'S RIGHT.

Back To Our Busy Day On The Farm

- Up & outside
- Weather & markets
- Organized & working
- Cell phone rings
  - "Hi, I'm with ___ and we have damning evidence of animal abuse on your farm. I need a response from you in 10 minutes or we will call in the media."

DOING WHAT'S RIGHT.

Do You Have An Action Plan?

- Have you thought about it?
- Talked about it?
- Done advance work?

- How would you respond?

DOING WHAT'S RIGHT.

Other Action Plans in Place

- Farm-level action plans
  - Manure management plan
  - Roster of contacts for emergencies
  - Breeding programs
  - Feeding programs
  - Pig flow plan
  - Crop rotation
  - Emergency Action Plan

DOING WHAT'S RIGHT.

Potential Farm Action Plan

- Contacted by PETA/HSUS/FARM…
  - Who is the lead/team
    - What are their responsibilities
      - Is the contact legitimate
      - Who needs to know
      - Who can help
      - Get the facts straight
      - What is the plan

DOING WHAT'S RIGHT.

Industry Assistance Is Available

- National Pork Board
- NPPC
- State Pork Association
- AASV
- Extension
- Law Enforcement

DOING WHAT'S RIGHT.

Potential Plan Segments

- Activist correspondence
- Employees
- Pork production
- Legal counsel
- Law enforcement
- External communications
  - Lenders, vendors, neighbors, community, media
- Industry relations

DOING WHAT'S RIGHT.

What Do You Need To Protect?

- Your family and employees
  - Safety first
  - Keep getting the work done while you fight the battle
- Your animals
  - What if your employees all quit
  - Who cares for your pigs
- Your reputation
  - Not just issue of pride
  - Issue of being able to do business

DOING WHAT'S RIGHT.

Possible Scenario: Opposition Comes Knocking

- They show up at the farm
- What is your action plan?
  - Know your legal rights
  - Who needs to be called?
  - Who will handle the situation?
  - What if your lead is not available?
  - Can they enter your barns?

DOING WHAT'S RIGHT.

Chances Are They Wont Be Alone

- News media covering the event
  - Looking for intensity, sensation, wild "sells"
- Demonstrators on your farm
  - What is your first step?
- Law enforcement levying animal cruelty charges
  - What are your rights?

DOING WHAT'S RIGHT.

In All Cases

- All employees need to know the plan
- Who is in charge and deals with this situation
- Who is their backup/assistant
  - Should be available to assist in any way
  - Take notes, listen, contact additional help

DOING WHAT'S RIGHT.

News Media At Your Gate… pointers

- Do you talk with them?
  - The cameras are always rolling
  - The opposition has told their story
- What should you say?
  - Legal implications
  - Moral implications
  - Community implications
- Do all employees know the plan?
  - "I need you to stay right there and I will get _____ to talk with you."

DOING WHAT'S RIGHT.

Prep Work Can Help

- Law enforcement
- Local media
- Community open house
- Community relations
- Know your supporters/detractors & what drives them
- ***Build Relationships Before You Need Them!***

DOING WHAT'S RIGHT.

Should You Engage With Opposition?

- Weigh the consequences
- Don't be held hostage
- Don't underestimate their strategy
- ***The best way to avoid confrontation is to assure your farm is doing it right!***

DOING WHAT'S RIGHT.

Mow-Mar As Example

- The owners of the farm were focused on doing the right thing in this situation
- They met with PETA
- They took corrective action
- The industry was able to tell the story

- ***The outcome would have been significantly different had the owners not followed those steps***

DOING WHAT'S RIGHT.

Mow-Mar Was a Team Effort

- Farm Owners
- New Farm Managers
- Previous Farm Managers
- National Pork Board
- National Pork Producers Council
- Iowa Pork Producer Association
- Minnesota Pork Producer Association
- American Association of Swine Veterinarians
- Hormel
- Iowa State University

DOING WHAT'S RIGHT.

Bottom Line---

- Do the right thing
- Tell your story before someone else tells their version
- Have your alliances and reputation in order before you need them

- ***Every single situation is an industry situation today!***

DOING WHAT'S RIGHT.

Emergency Action Plan

- Web-based www.pork.org
- Site-specific
- Share with employees
- Share with emergency responders

- ***Prior planning is the key to successful outcome in crisis situation!***

DOING WHAT'S RIGHT.

It Happened in These States

- Ohio
- Minnesota
- Missouri
- Iowa
- North Carolina
- Texas
- Pennsylvania
- Oklahoma

DOING WHAT'S RIGHT.

You Are Not Alone

- National Pork Board
- National Pork Producers Council
- State Association
- American Association of Swine Veterinarians
- Extension

- Work as an industry response to help you!

DOING WHAT'S RIGHT.

Every Situation Impacts Us All

- Have your house in order
- Know your plan
- Build your relationships early

- ***Do the right thing every single time***

DOING WHAT'S RIGHT.

Questions

- This message funded by America's Pork Checkoff Program.

SWINE PROFITABILITY CONFERENCE

February 28, 2012

"Appendix Articles"

by
Mike Tokach, Joel DeRouchey, Bob Goodband,
Steve Dritz, and Jim Nelssen
K-State Swine Nutrition Team

…..Notes…..Notes…..Notes…..Notes

Diet Formulations using Lower Energy Feeds

Mike Tokach, Joel DeRouchey, Bob Goodband, Steve Dritz, and Jim Nelssen
K-State Swine Nutrition Team

Because of the rapid increase in ingredient prices in recent years, swine producers have explored alternative ingredients and alternative formulation strategies in attempts to minimize feed costs. A strategy that makes sense for some producers is to lower the energy density of the diet, either by removing dietary fat or by using lower energy ingredients. In this paper and presentation, we will explore the impact of using lower energy diets and help provide guidelines to make sure that all potential ramifications are considered.

For many of us, feeding a low energy diet used mean feeding a grain-soybean meal based diet without added fat. Of course, when we talk about low energy diets now, not only is the energy level of the diet reduced, but the fiber content is often greatly increased as corn and soybean meal are displaced with ingredients, such as wheat byproducts (middlings, shorts, bran, etc), canola meal, soybean hulls, corn byproducts (distillers grains, germ, bran, etc), or other high fiber ingredients. The impact of the fiber components are often difficult to separate from the impacts of the energy level itself when assessing the influence of lower energy diets on pig performance.

What happens when pigs are fed lower energy, higher fiber diets?

- ADG is usually reduced; however, the magnitude depends on genetics, energy level, and environment
- Feed efficiency is always worse
- Carcass yield is reduced (again magnitude varies, but yield will go down due to increase in large intestine content and weight)
- Bulk density of the diet is reduced, thus, transportation cost can increase if more loads of feed are required and a lower quantity (weight) of feed can be stored at the production site.
- Although relatively minor compared to other impacts, iodine value, which is an indicator carcass fat softness, has increased in some trials indicating carcass fat is softer for pigs fed lower energy, higher fiber diets. The reason for this response may be because fat usually becomes a higher percentage of dietary energy in high fiber diets and because pigs fed diets with higher fiber levels usually have less backfat, which leads to higher iodine values.
- Manure systems are influenced by an increased volume of manure production and manure that may result in more retained solids in storage facilities.

The key to understanding whether low energy diets are economically justified is to understand whether the costs of these negative impacts are offset by the diet cost savings from using the low energy ingredients. So how do you go about estimating these impacts?

Assigning nutrient values for an ingredient. First, we need to know the nutrient values for the low energy ingredient to understand how much dietary energy will be reduced with the inclusion. Assigning nutrient values is not as easy as it sounds. Nutrient values can be obtained from published sources, calculated from laboratory assays, estimated from nutrient values of other ingredients, or a combination of all of the above. All of these approaches have their own issues and none are perfect. Often, lower energy ingredients are more variable in composition than corn and soybean meal and the variability must be considered in formulation to avoid over-valuing the ingredient.

The nutrient that is most difficult to estimate because it cannot be measured directly in a laboratory is metabolizable or net energy. Energy values can be estimated from chemical analysis for other nutrients, such as moisture, NDF, ADF, crude fiber, starch, fat, and crude protein; however, the equations used for the estimates were, most often, not developed with the ingredient that you want to estimate an energy value for.

There are several sources of equations that can be used to estimate the energy value of an ingredient including NRC (1998); INRA (2004); or Rostagno (2011).

If using a standard equation to estimate energy value, the value being estimated should be related to the energy value of a known ingredient, such as corn, and the percentage change in energy relative to the value for corn with the same equation should be used to estimate the energy value for the ingredient in your formulation matrix. For example, corn has a ME content of 3,420 kcal/kg in NRC (1998). Using a standard equation, you may calculate that the ME of wheat midds as 2,706 from chemical analysis of your source of wheat midds. This is 79% of the energy value of corn. However, if you obtain a chemical analysis of your corn from the same lab that analyzed your wheat midds and used the same equation that you used to estimate the energy value of wheat midds, you may estimate the energy value of corn at 3,300 kcal/kg. Thus, the wheat midds would have 82% (2,706/3,300) of the energy value of corn. Thus, you would want to multiply the 82% times 3,420 to put the wheat midds energy value on a NRC equivalence to compare to the energy value of corn from NRC (1998). Thus, the energy value for this wheat midds source would be estimated at 2,804 (82% x 3420) instead of 2,706 kcal/kg. The important point here is to not use a standard equation to estimate the energy value for one ingredient and use a book value to estimate the energy value for another ingredient. It is also important to use the same lab and same estimation equation for the known ingredient as the unknown ingredient. They need to be compared on the same basis.

Impact of dietary energy on ADG, ADFI, and F/G. As the energy density of the diet increases for pigs under field conditions, most pigs have linear improvements in ADG through the highest energy level that can be fed. The only time that this does not occur is when pigs consume feed beyond their needs for maximal protein deposition. This can occur with sick pigs that have lowered levels of protein deposition or for healthy pigs with very high levels of feed intake. The rate of improvement in ADG with each change in energy density can vary; however, for calculations, a simple rule of thumb is that ADG increases by about 3% for every 100 kcal/kg increase in ME content of the diet. Conversely, ADG decreases by 3% for every 100 kcal/kg decrease in ME content of the diet.

Another part of the reason that there is variability in the impact of dietary energy on ADG is that some low energy ingredients have more negative impact on ADFI than others. As dietary energy is decreased, pigs often increase feed intake, such that energy consumption is not reduced as much as the diet energy was reduced. However, as energy density decreases further and certain fiber components increase in the diet, the pigs cannot continue to consume more feed. Thus, feed intake and energy intake eventually decrease. This is one of the reasons that moderate fiber levels can have a smaller negative impact on growth performance relative to the large negative effect of higher levels.

The most consistent response to decreasing dietary energy is poorer feed efficiency. If the diet energy is valued correctly, feed efficiency will worsen linearly as dietary energy decreases.

Estimating cost of the decreased growth rate. The cost of the poorer F/G with lower energy diets is easy to determine because feed cost per pig must still be lower with the higher feed usage to make the lower energy diet economical. Assigning the economic value on growth rate on the other hand is a bit more difficult. The key question that must be answered is whether pigs can achieve the same ideal market weight when low or high energy diets are fed. If excess space is available, such as in the winter time, the cost of the reduced ADG may be low and only a factor on the last pigs removed from the barn. If however, space is limited, such as during the summer months, the decreased ADG must be valued on a margin over feed basis and can quickly nullify any advantage of reduced diet cost from using a lower energy diet, especially when market prices are considerably higher than feed costs.

What about the value and level of impact on other variables? As mentioned above, reductions in dietary energy are accompanied by increases in dietary fiber components. The increases in dietary fiber lead to increases in large intestine weight at market. Thus, yield is reduced. Pigs fed high fiber, lower energy diets usually have reduced backfat, which further reduces yield. The impact of dietary energy on yield can be variable, but a value of 0.25% reduction in yield for every 100 kcal/kg reduction in dietary energy can provide an estimate for base economic calculations. If increasing the lean percentage will further increase lean premium, the positive impact of lowering energy density on lean percentage should be included in the economic equation.

The cost of decreasing the bulk density of the diet will vary greatly depending on how feed is processed and delivered. Low energy diets will increase the volume required to transport and store the same quantity (tons) of feed. For example, most feed mills have found that 3 tons of a diet containing 30 to 40% by-products (DDGS and wheat middlings for example) cannot fit into a 3 ton mixer. Feed trucks often cannot maximize the legal weight capacity of the truck because the feed simply won't fit into the compartments. Thus, some mills have purchased mixers with a larger volume and other mills are mixing a smaller quantity with each batch. Both of these solutions add cost to the system.

Currently considerable research is being conducted to determine whether further processing of the high fiber ingredients, such as reducing particle size, will increase their feeding value. These costs will also need to be accounted for in estimating the value of high fiber ingredients.

The softness of the fat, which is often measured as the iodine value of the fat, is more closely related to dietary fat content and composition than fiber level. However, it does appear that feeding low energy diets can increase the unsaturation of the body fat stores, which results in higher iodine value readings. This impact can be small at only 1 or 2 mg/g, which is similar or smaller than the difference between barrows and gilts, but should be considered if iodine values are close to the processors maximal permissible value.

Another potential downside of feeding higher fiber diets that needs to be considered is variability. The low energy ingredient itself can often be much more variable in composition than the grain and soybean meal that it is replacing in the diet. Also, some trials indicate that lowering the energy density of the diet can increase the variability in growth rate of pigs in the barn. Again, this is a minor consideration compared to the impacts on pig performance and carcass yield; however, it should be considered.

Can the negative effects be reduced through management strategies? Considerable research is currently being done to minimize the negative impact of feeding lower energy, high fiber diets. While all the negative effects cannot be eliminated, it does appear that we can reduce the impact by switching pigs to higher energy diets for 3 or more weeks before market. For example, in a recent trial, we found (Asmus et al., 2011; Table 1) that withdrawing pigs from a high NDF diet containing DDGS and midds before market can improve F/G, carcass yield, iodine value, and reduce large intestine weight; however, the optimal length of withdrawal depends on the response criteria targeted. Shorter withdrawal was sufficient to recover the yield response; however, longer withdrawal was needed to make greater changes in overall feed efficiency or iodine value.

Do enzymes provide more benefit in low energy diets? In theory, pigs fed lower energy, higher fiber diets should benefit more from added enzymes than pigs fed grain-soybean meal based diets because the higher fiber diets provide more substrate for the enzymes. Unfortunately, most of the data to this point indicates that although certain enzymes can improve the digestibility of certain fiber components, the benefit is not great enough or consistent enough to provide a general recommendation to include particular enzymes in low energy diets.

Summary. Because of the high cost of grain, it appears that use of lower energy, higher fiber diets will continue to increase. With increased use, we will become more accurate with our estimates of the energy content and other nutrient values for these ingredients. We may change our systems to allow more time to achieve the same market weight achieved with higher energy diets. Owning more space and feeding lower energy diets may be more economical than feeding higher energy diets. We will also increase our understanding of the impact of their use on pig performance and carcass composition. Most importantly, we will become increasingly adept at developing feeding strategies that maximize the use of these ingredients while minimizing their negative impacts.

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Table 1. Effect of dietary neutral detergent fiber (NDF) level prior to marketing on finishing pig performance and carcass characteristics[1]

	Treatment						
	1	2	3	4	5	6	
d 0 to 43:	Low[2]	High[3]	High	High	High	High	
d 43 to 67:	Low	Low	Med[4]	High	High	High	
d 67 to 90:	Low	Low	Med	Low	Med	High	SEM
Day 0 to 90							
ADG, g	885	898	903	894	894	894	9
ADFI, kg [a]	2.56	2.62	2.64	2.68	2.68	2.70	0.05
F/G [a]	2.90	2.92	2.92	3.00	3.00	3.02	0.03
Carcass characteristics							
Yield, % [5,a,b]	73.2	72.9	71.6	73.0	72.4	71.7	0.26
HCW, kg	88.13	88.81	87.86	88.68	87.77	86.82	1.15
Backfat depth, mm [6,a]	18.8	18.5	17.5	18.3	19.1	16.8	0.5
Loin depth, mm [6]	58.4	59.7	58.7	59.2	57.2	59.2	1.0
Lean, % [6]	53.0	53.4	53.6	53.3	52.7	53.9	0.31
Jowl iodine value [a,b]	68.4	70.6	75.8	74.8	76.6	78.5	0.94
Large intestine, kg [a,b]	2.98	3.23	3.71	3.03	3.39	3.94	0.21

[1] A total of 264 pigs (PIC 327 × 1050, initial BW= 40.9 kg) were used in this 90-d trial.

[2] Low = corn-soybean meal diet with 0% DDGS and 0% midds with NDF of 9.3%.

[3] High = corn-soybean meal diet with 30% DDGS and 19% midds with NDF of 19%.

[4] Medium = corn-soybean meal diet with 15% DDGS and 9.5% midds with NDF of 14.2%.

[5] Percentage yield was calculated by dividing HCW by live weight obtained at the farm before transport to the packing plant.

[6] Carcass characteristics other than yield and iodine value were adjusted by using HCW as a covariate.

[a] Linear effect of withdrawal time $P < 0.01$.

[b] Fiber level fed during withdrawal $P < 0.05$.

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Amino Acid Requirements of Growing Pigs

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Abstract

Considerable research has been published in the last 10 years on the amino acid requirements of growing pigs. Over 80 publications are briefly summarized in this review and undoubtedly numerous publications have inadvertently not been included. Data indicates the best practical method to express lysine requirements over a wide range of environmental conditions and genetics may be in relation to growth rate with nursery pigs requiring approximately 19 g of SID lysine/kg of gain and finishing pigs requiring approximately 20 g/kg of gain. These requirements have increased over time. For practical diet formulation, other amino acids are best expressed as a ratio relative to lysine. The research published in recent years greatly improves our understanding and allow us to propose lysine requirement estimates and ratios for other amino acids for each dietary phase of growth.

Introduction

Numerous papers have been written on amino acid requirements of growing pigs and methods to assess and express requirements. In this paper, we will focus on research conducted from 2000 to 2010 and on empirical studies rather than the factorial approach to determine requirements. In collecting information for this paper, we were surprised by the relatively few publications on the lysine requirement of growing and finishing pigs and the large number of trials that have been conducted to determine the relative ratios of other amino acids relative to lysine.

The requirements for amino acids can be expressed as a percentage of the diet, grams per day, grams per unit of energy, or grams per unit of body weight. For lysine, all of these methods will be used. The requirement for other amino acids will be expressed as ratio relative to lysine. Amino acids can also be expressed on a total basis, apparent digestible basis, true digestible basis, or standardized digestible basis. As has become the standard for diet formulation, standardized ileal digestible (SID) amino acids will be used in this paper.

One area that we will not address in this paper is the wide variability in amino acid levels within and between ingredients and between laboratories. These differences exist and must be dealt with when formulating swine diets. For the purposes of this paper and our research at Kansas State University, ingredient SID amino acid and ME levels provided by NRC (1998) were used in diet formulation for experiments and for comparisons to have a common point of reference. To compare any amino acid recommendation from this paper, it is best to formulate a corn-soybean meal diet with your ingredient loading values and NRC (1998) ingredient loading values for the amino acids and energy to adjust the recommendations to your ingredient nutrient loadings. For ease of comparison, the optimal ratios relative to lysine are provided using NRC (1998) ingredient nutrient loadings and converted to Brazilian (Rostagno, 2005) ingredient nutrient values.

Lysine requirements

Nursery pigs

Numerous research trials have explored the SID lysine requirement of nursery pigs in recent years. Researchers at Kansas State University and the University of Missouri conducted a series of experiments under field and university conditions to determine the lysine requirement from 5 to 10 and 10 to 25 kg. For the lighter weight range, the requirement estimate was found to be between 1.35 and 1.40% SID lysine (4.0 to 4.2 g/Mcal ME; Gaines el al., 2003; Nemechek et al., 2011b). This requirement was similar to the estimate found by Dean et al. (2007) of 1.4% SID lysine or 18.9 g of lysine per kg of gain for 6 to 12 kg pigs.

For 10 to 25 kg pigs, Kendall et al. (2008) conducted 5 experiments with 3,628 pigs and found the SID lysine requirement to be 1.30% SID lysine (3.80 g/Mcal ME). This was equivalent to 19 g of SID lysine per kg of gain. Schneider et al. (2010) titrated energy and lysine levels simultaneously in two separate trials with different genotypes. With one genotype, the optimal SID lyine:ME ratio was approximately 3.4 to 3.6 g/Mcal ME, while the optimal ratio was 3.9 to 4.2 g/Mcal ME for the other genotype. However, when expressed relative to gain, the requirement was approximately 19.0 g of SID lysine/kg of gain for both genotypes. In another large field study, Lenehan et al., (2003) found the SID lysine requirement for 10 to 20 kg pigs was 1.40%; however, when calculated on a g/kg of gain basis, the optimal level was again 19 g of SID lysine/kg of gain. In a cooperative study involving several universities in the United States, Hill et al. (2007) confirmed that the lysine requirement of nursery pigs of modern genotypes were higher than recommendations of NRC (1998).

Although lysine requirements of nursery pigs have increased in recent years and vary with environmental conditions and genotype, when expressed relative to growth rate, empirical studies in recent years have consistently found the requirement to be 19 g per kg of gain.

Finishing pigs

Interestingly, more experiments have been published in recent years on the lysine requirement of nursery pigs than the lysine requirement of finishing pigs. Numerous trials have been conducted within production systems to assess the lysine requirements of finishing pigs under field conditions; however, relatively few of those experiments have been published as most are proprietary to the production system where the experiments were conducted. Main et al. (2008a) and a few abstracts (Srichana et al., 2004ab; Gaines et al., 2004a; Bergstrom et al., 2010) are the only lysine titration experiments published in recent years. PIC (2008) also conducted a series of lysine titration trials to determine their recommended Lys:ME ratios.

Certainly, the lysine requirements of finishing pigs are even more variable than the requirement of nursery pigs due to the wide range of genetic capability for lean growth, health status, energy intake, and environmental conditions. Our discussion will focus on the requirements of high lean growth modern genotypes that would be expected to have a protein accretion rate of approximately 150 g/d (lean gain of 0.85 lb/d or 385 g/d). For lysine recommendations for pigs with lower protein deposition rates, the National Swine Nutrition Guide (2010) provides methodology for estimating their lysine requirements.

Main et al. (2008a) conducted a series of 7 experiments to determine the lysine requirement of growing-finishing gilts and barrows under commercial conditions. The equations (lysine:calorie ratio, g/Mcal ME = - 0.0133 × BW, kg + 3.6944 and = - 0.0164 × BW, kg + 4.004, for barrows and gilts, respectively) best described the Lys:calorie ratio that met biological requirements and optimized income over feed cost (IOFC) of the pigs (PIC, L337 × C22; 35 to 120 kg) tested in their experiments. On an SID basis, the optimal ratios from their experiment would be: (Lys:ME, g/Mcal = - 0.0116 × BW, kg + 3.214 and = - 0.01427× BW, kg + 3.483 and, for barrows and gilts, respectively). These studies also suggest lower feed cost per kg of gain could be obtained with only marginal reductions in biological performance and IOFC when feeding marginally deficient lysine diets early (35 to 70 kg) in the grower-finishing period, as compared to more severe penalties in growth and economic performance of feeding marginally deficient diets in late finishing period (70 kg to slaughter). When expressed relative to gain, the optimal SID lysine requirement was 20 g per kg of gain. Although De La Llata (2007) found lower SID lysine requirements on a percentage basis, the SID lysine required per kg of gain was also 20 g/kg in their studies.

Bergstrom et al. (2010) conducted four 28-d experiments with mixed genders (barrows and gilts) to determine the lysine requirement of growing-finishing pigs (PIC TR4 × 1050) from 37 to 129 kg. Their results indicated that for pigs weighing 37 to 65 kg, 56 to 86 kg, 80 to 107 kg, and 102 to 129 kg, performance and IOFC were optimized with SID lys:cal ratios of 2.69, 2.35, 2.09, and 1.79 g/Mcal ME, respectively. These results closely match the ratios suggested by Main et al. (2008a) and those suggested by PIC (2008) for gilts of their genotype (SID lysine, g/mcal ME = 0.000027 × $(BW, kg)^2$ - 0.015318 × BW, kg +4.114302).

Researchers at the University of Missouri have published SID lysine estimates for 30 to 44 and 44 to 67 kg PIC gilts (Srichana et al., 2004a) and 80 to 100 kg barrows and gilts (Srichana et al., 2004b). Similar to other researchers, their data suggests the requirement for optimal F/G is higher than the requirement for optimal ADG. Although they list the estimates as a percentage of the diet, using their data, the estimated requirement is similar to the 20 g/kg of gain estimated by other researchers. In a recent experiment, Shelton et al. (2009) again confirmed that 20 g SID lysine per kg of gain resulted in optimal performance of 55 to 80 kg gilts.

It is well accepted that lysine requirement estimates from NRC (1998) are deficient for higher lean growth pigs when expressed on a percentage basis; however, the reason for the lower recommendations of NRC appears to be entirely due to the feed intake curve used to generate the estimates. Feed intake with high lean genotypes is lower than the estimates used in NRC (1998), particularly under field conditions. The recently published National Swine Nutrition Guide (2010) used the NRC model to estimate protein deposition and lean growth curves to estimate the lysine requirement on a grams per day basis. The authors then used feed intake from recent publications of field studies to generate a more current feed intake curve. Using this methodology, the estimated amino acid requirements estimated in the publication can be expressed relative to ME with the equation (lysine:ME, g/Mcal = -0.00000146 × $(BW, kg)^3$ + 0.00041 × $(BW, kg)^2$ - 0.051 × (BW, kg) + 4.502) for barrows with a protein accretion rate of 150 g/d. This lysine to energy requirements predicted with this equation match the estimates from the empirical studies described above for pigs from weaning to 125 kg reasonably well. The requirement for gilts with similar protein accretion is slightly higher (Table 1).

Based on the publications and experiments described above, lysine requirements of pigs under field conditions can be estimated using one of the following methods:

1) Published values from empirical studies, such as those of Main et al. (2008a) or PIC (2008), obtained with pigs housed in field conditions can be used as a reasonable first estimate. Using the data described above, the lysine:ME ratio for barrows with 150 g of protein deposition from 20 to 120 kg can be described by the equation (g/Mcal = $0.000146 \times (\text{BW, kg})^2 - 0.0377 \times (\text{BW, kg}) + 4.352$; Table 1).

2) Use of 20 g of SID lysine per kg of gain appears to be a reasonable estimate of lysine requirements. Thus, once a growth curve and feed intake curve are obtained from pigs within a production system, the lysine requirement curve can be estimated with reasonable accuracy. It is important to know the energy content of the diets fed while obtaining the feed intake curve in order to accurately estimate a lysine:ME ratio, which will be needed if the dietary energy level is changed.

3) Requirements can be estimated using a factorial approach using the lysine requirement for maintenance and weight gain as suggested by Rostagno (2005).

4) The lysine requirement can be modeled by estimating the protein accretion or lean growth curve and feed intake curve, such as the method suggested by NRC (1998) and used in the National Swine Nutrition Guide (van Heugten, 2010). This method can be further enhanced by actually measuring the protein and fat deposition curves using real-time ultrasound as suggested by Schinckel and de Lange (1996) and Smith et al. (1999). These authors have found that actually measuring the shape of the protein and fat deposition curves is particularly helpful when dealing with unfamiliar genotypes, health statuses, or environments.

5) Feeding titration experiments conducted in commercial scale field research barns, such as those available in many North American production systems, provide the best estimates of the pigs' actual responses to altering the lysine content of the diet.

Because ractopamine hydrochloride increases protein deposition when fed in late finishing, the lysine requirement increases when ractopamine is fed. Numerous trials have indicated that the SID lysine:ME ratio for pigs fed diets containing ractopamine in the late finisher (> 100 kg) should contain approximately (0.92% to 0.95% SID lysine or 2.75 to 2.85 g/Mcal ME (Neill et al., 2006; Frantz et al., 2009; Hinson et al., 2008).

The lysine requirement of entire male pigs immunized against GnRH is discussed in another paper in these proceedings and will not be addressed here.

Influence of lysine fed during one phase on subsequent performance.

Although the lysine level fed in one phase does not have a tremendous impact on the response in subsequent phases, some evidence suggests that pigs will partially compensate for feeding of deficient diets early in life when fed diets adequate in lysine later in the nursery (Nemechek et al., 2010) or finisher stage (Gaines et al., 2002; Collins et al., 2006; Main et al., 2008b).

As an example, Main et al. (2008b) fed diets at or below the pigs requirement in the early finisher and at, below or above the requirement in the late finisher. Overall, pigs fed Lys-deficient diets in early finishing, and at the estimated lysine requirement in late finishing, had lower feed cost per kilogram of gain and similar IOMFC compared with pigs fed at the estimated lysine requirement in both early and late finishing. As long as lysine requirements are met in late finishing, feeding slightly less than the lysine requirement in early finishing can reduce costs without sacrificing overall IOFC.

This ability of pigs to somewhat compensate for previous lysine deficiencies can make the determination of lifetime amino acid requirements problematic. Ideally, the optimal amino acid level to maximize profitability would be fed in each dietary phase. However, if the lysine requirement is not known, the nutritionist should error towards the lower end of lysine estimates in the earlier stages of life and the higher end of estimates in the later stages of the finisher period. The cost in reduced growth rate, poorer feed efficiency, and lowered carcass leanness due to under-formulation in the late finisher is much greater than in the nursery or grower period.

Threonine:lysine ratio

The large difference between apparent and standardized digestibility values for threonine has caused some confusion by nutritionists with this amino acid over the years. Deficiencies of threonine cause real, but relatively small reductions in growth and efficiency as compared to deficiencies of the other major amino acids. This has led to an underestimation of requirements and under-formulation for threonine by many nutritionists.

van Milgen and Le Bellego (2003) conducted a meta-analysis of 22 different studies and found the optimal threonine:lysine ratio increased from 58% at 15 kg to 65% at 110 kg using a linear-plateau model. Use of curvilinear models resulted in higher requirement estimates. In two separate experiments, Lenehan et al. (2003, 2004) found an optimal threonine:lysine level of 64 to 66% for 10 to 20 kg pigs. James et al. (2003) also found the optimal threonine:lysine ratio to be 60 to 65% for 10 to 20 kg pigs. Although Wang et al. (2006) did not report a SID threonine:lysine ratio, the growth rate of pigs in their study can be used to estimate the SID lysine requirement (19 g/kg of gain) to calculate an SID threonine:lysine ratio. Their data would suggest the ratio is at least 60% of lysine for growth and 67% for immunity. Li et al. (1999) also demonstrated that the threonine requirement for immunity was higher than the requirement for growth.

For finisher pigs, Frank et al. (2001) demonstrated that the SID threonine:lysine ratio was approximately 65% for 34 to 65 kg pigs. This ratio is identical to the optimal ratio suggested by the data of Buraczewska et al. (2006). The SID threonine requirement of growing pigs was estimated at 10.3 g/d by Ettle et al. (2004). Assuming growing pigs require 20 g of SID lysine per kg of gain, a SID threonine:lysine ratio of at least 60% can be calculated for 35 to 65 kg pigs from their data. Plitzner et al. (2007) found an optimal SID threonine:lysine ratio of 62 to 64% with 67 to 113 kg pigs and also suggested that the ratio rises as pigs move towards the late finishing stage. Pedersen et al. (2003) also found a similar optimal threonine:lysine ratio of 62 to 64% for finishing pigs; however, Frantz et al. (2005) found the threonine requirement increased to 67% of lysine for 75 to 105 kg pigs. Wecke and Liebert (2010) conducted a series of N balance studies and found the optimal SID threonine:lysine ratio of 61% for 30 to 110 kg pigs. Research shows that the minimum requirement for threonine relative to lysine is approximately 60 to 62% in the nursery stage and rises to 64 to 67% in the late finishing stage (Table 2). A ratio of 65% using NRC (1998) ingredient nutrient values is equivalent to a ratio of 68 to 69% using Brazilian ingredient nutrient values of Rostagno (2005; Table 3).

TSAA:lysine ratio

Ever since Hahn and Baker (1995) suggested that the total sulfur amino acid requirement during late finishing was 65%, numerous trials have been conducted with methionine and cystine. It is generally assumed that methionine must constitute at least 50% of the TSAA ratio (NRC = 48%

on weight basis); however, recent data (Gillis et al., 2007) suggests that methionine may need to be slightly greater (55% on weight basis; 50% on molar basis) than cystine in the ratio.

For nursery pigs, Dean et al., 2007 suggested that the requirement for total sulfur amino acids was 10.1 g/kg gain or 54% of lysine for 6 to 12 kg pigs. Gaines et al. (2005) found a slightly higher ratio of 57 to 61% depending on the response criteria and method of assessing the breakpoint with 8 to 26 kg pigs. Yi et al. (2006) found a similar TSAA:lysine ratio of 58% for optimal ADG with 12 to 24 kg pigs. In a series of experiments, Kansas State University researchers found a similar range of SID TSAA:lysine ratios of 57 to 60% for 10 to 20 kg pigs with Genetiporc (Schneider et al., 2004) and PIC (Schneider et al., 2006) pigs.

In two separate experiments with growing pigs, Gaines et al. (2004b,c) found the optimal TSAA:lysine ratio was 60% for 29 to 45 kg and 45 to 68 kg pigs. Lawrence et al. (2005) found a similar optimal level of 60% for 30 to 60 kg pigs. For late finishing pigs, the data is not as clear. Although Hahn and Baker (1995) suggested a ratio of 65%, Knowles et al. (1998) found a much lower optimal ratio (< 60%) for 77 to 110 kg gilts for all response criteria except to minimize fat accretion, which required 65%. Frantz et al. (2009) found the optimal TSAA:lysine level was 58% for late finishing pigs fed ractopamine HCl. It appears that the TSAA:lysine ratio for growing pigs is between 55 and 60% and may increase slightly as pigs reach market weight, unless ractopamine is fed.

Tryptophan:lysine ratio

Research on the optimal tryptophan to lysine ratio is difficult to conduct. Because of the relatively small inclusion rates and small differences in range of tryptophan levels tested (ex. 14 to 22% of lysine), diet manufacturing is a challenge to ensure the very low additions are thoroughly mixed. Also, tryptophan is a difficult amino acid to analyze and different analytical techniques yield different results adding to the confusion. There is also disagreement in the quantity of tryptophan present in key basal ingredients used in many of the research trials, which can dramatically impact the projected ratios because the basal ingredients make up such a large proportion of the tryptophan in test diets. Finally, the level of other large neutral amino acids in the diet may influence the response to increasing tryptophan levels. The optimal tryptophan:lysine ratio suggested by most researchers ranges from 16 to 20%. Although this range is relatively small, the difference can lead to large changes in diet formulation and cost and inclusion of other crystalline amino acids in the diet.

On the low end of the recommended range for nursery pigs, Ma et al. (2010b) suggested that the SID tryptophan:lysine requirement may be as low as 15% for 11 to 22 kg pigs; however, data from Nemechek et al. (2011a) demonstrates that 15% SID tryptophan:lysine results in lower ADFI and ADG than a ratio of 20%. Guzik et al. (2002) estimated the SID tryptophan requirement for nursery pigs at 0.21, 0.20, and 0.18% of the diet for 5.2 to 7.3 kg, 6.3 to 10.2 kg, and 10.3 to 15.7 kg pigs, respectively. Using the SID lysine levels suggested above, these ratios would all be less than 16% of lysine. Jansman et al. (2010) found higher estimates for SID tryptophan for 10 to 20 kg pigs, both as a percentage of the diet (0.22%) and as a ratio to lysine (21.5%). In a review of 33 experiments, Susenbeth (2006) summarized that the SID tryptophan:lysine requirement is below 17.4% and likely near 16.0%. Susenbeth (2006) also concluded that feeding at 17% would include a safety margin to cover most of biological variations and that the tryptophan:lysine ratio seemed to be unaffected by body weight, growth rate, lysine and protein concentration in the diet, or genetic improvement of the animals.

There is conflicting data on the impact of sanitary conditions on the tryptophan requirement of nursery pigs. Le Floc'h et al. (2007) found that the requirement to pigs in low sanitary conditions may have a higher response to tryptophan due to the increased requirement of the immune system. However, Frank et al (2010) found the opposite response with pigs having a greater response to increasing trp:lys in clean environment than in a dirty environment.

The optimal tryptophan:lys requirement for finishing pigs also is a contentious issue. In a first experiment with 25 to 40 kg pigs, Quant et al. (2007) estimated that the SID tryptophan:lysine requirement was 15.6% for 25 to 40 kg pigs. In a second experiment, where they increased the levels of other essential amino acids in the diet, they found a higher estimate of 17% (Quant et al, 2009). Guzik et al. (2003) did not suggest SID tryptophan:lysine ratios, but reported SID tryptophan requirements of 0.18, 0.14, 0.11, and 0.11 for 30, 50, 70, and 90 kg pigs respectively. These levels were confirmed by Ma et al. (2010a). Guzik et al. (2004) suggested a trp:lys requirement of 19.5% for pigs fed wheat/barley based diets and found that the ratio was not different whether the threonine:lysine ratio was 60 or 65%; however, there was no response to tryptophan when the Thr:lysine ratio was 55%, which is now known to be deficient. Kendall et al. (2007) found that the SID tryptophan:lysine ratio was not greater than 17% in late finishing (90 to 125 kg) barrows. Hinson et al. (2010) conducted three experiments with 27 to 45, 67 to 85, and 96 to 117 kg pigs and found an optimal SID tryptophan:lysine ratio of 16% over the entire weight range.

We believe that feeding less than 16.5% SID tryptophan:lysine greatly increases the risk for poorer ADFI and growth rate. However, more research is clearly needed to document the value of increasing the SID tryptophan:lysine ratio from 16.5 to 20% or greater. We also need better understanding of the potential interaction between health statuses and tryptophan and the role of other large neutral amino acids on the requirement for tryptophan. We also need a clearer understanding of the actual tryptophan levels in feed ingredients and how they are influenced by laboratory method used for the analysis. A ratio of 16.5% using NRC (1998) ingredient nutrient values is equivalent to a ratio of 17 to 17.5% using Brazilian ingredient nutrient values of Rostagno (2005).

Valine:lysine ratio

Although there are some differences in the estimates for the optimal valine:lysine ratio, we believe that much of the difference may be in the basal valine and lysine levels used in diet formulation. If you formulate the same corn-soybean meal diets with crystalline amino acids using NRC (1998) and INRA or Brazilian (Rostagno, 2005) amino acid values for the corn and soybean meal, a diet containing 65% SID valine:lysine with NRC values will contain 68% SID valine:lysine with INRA values and 69% with values from Rostagno (2005). These differences are minor, but may explain much of the difference between the valine:lysine estimates of 70% from Europe (Barea et al., 2009a) compared with 65% from the United States (Gaines et al., 2010)

Numerous valine trials have been published in the last 10 years. Mavromichalis et al. (2001) was one of the first publications to suggest that the valine requirement of nursery pigs was greater than the level suggested by NRC (1998). Their data suggested that 10 to 20 kg pigs required 12.5 g of SID lysine per kg of gain. Gaines et al. (2010) found a similar requirement of 12.3 g of SID lysine/kg of gain for 13 to 32 kg pigs. Using the requirement of 19 g of SID lysine per kg of gain for nursery pigs found by several researchers and discussed earlier in this paper, a SID Lys:ME ratio of 66% can be calculated, which is similar to the 65% reported by Gaines et al. (2010) for 13 to 32 kg pigs and 65 to 67% reported by Wiltafsky et al. (2009b) for 8 to 25 kg pigs. The 65% SID valine:lysine ratio was recently confirmed by Nemechek et al. (2011a) using 7 to 12 kg pigs. A ratio of 65% using NRC (1998) ingredient nutrient values is equivalent to a ratio of 69% using Brazilian ingredient nutrient values of Rostagno (2005).

Isoleucine:lysine ratio

Similar to other amino acids, our understanding of the optimal ratios of isoleucine to lysine has increased greatly in the last 10 years. The main confusion in understanding the optimal isoleucine to lysine ratio is the interaction between isoleucine and other branch chain amino acids, in particular leucine.

Spray dried blood cells have been used in several isoleucine studies to create a basal diet with a low isoleucine:lysine ratio (Parr et al., 2003, 2004; Kerr et al., 2004). The problem is that blood cells contain high leucine levels, which later were determined to increase the isoleucine:lysine recommendation. Subsequently, Fu et al (2005a,b), Fu et al (2006a,b,c), Dean et al. (2005), and Wiltafsky et al (2009a) demonstrated that the SID isoleucine:lysine requirement was 60% or greater in diets containing blood meal or blood cells and closer to 50% for diets without high levels of blood cells. The requirement of 50% or less for SID isoleucine:lysine when blood cells are not included in the diet was confirmed by Barea et al. (2009b) for 11 to 23 kg pigs. Lindemann et al. (2010) also found the SID isoleucine:lysine requirement to be between 48 and 52% for ADG. Norgaard and Fernandez (2009) found that increasing the isoleucine:lysine ratio from 53 to 62% did not influence performance of 9 to 22 kg pigs. Dean et al (2005) also suggested that 50% isoleucine:lysine ratio was adequate for 80 to 120 kg barrows fed corn-soybean meal diets. It appears that the SID isoleucine:lysine is less than 52% for diets don't contain a protein source that provides excess leucine in relation to the isoleucine level, such as blood products. Caution is advised with all branch chain amino acids; however, as feeding as little as 5% below the minimum ratio (ex. 45 vs 50% of lysine) will greatly reduce feed intake and daily gain.

Nonessential amino acid requirement

Although the order can vary with different dietary ingredient mixtures, typically the first 5 limiting amino acids for most practical diets are lysine, threonine, methionine, tryptophan, and valine. However, formulating diets with high levels of synthetic amino acids to the optimal ratio for the first 5 limiting amino acids often has resulted in poorer performance than diets with higher levels of intact protein sources. Kendall et al. (2004) found that certain nonessential amino acids (Ex. glycine) were required in corn-soybean meal diets with high levels of synthetic lysine and that the nitrogen could not be provided by nonprotein nitrogen. In a series of experiments, Powell et al. (2009a,b) and Southern et al. (2010) found that glycine and another amino acid to provide nitrogen were required in diets formulated to the fifth or sixth limiting amino acid in order to maintain feed efficiency at similar levels to control diets.

Another method to ensure that the diet contains enough nonessential amino acids is to place a maximum on the total lysine to total crude protein ratio in diet formulation. The biological basis for a lysine:CP ratio originates from the level of total lysine as a percentage of crude protein in muscle, which ranges from 6.5 to 7.5% (NRC, 1998). Although an average lysine:CP ratios of 6.8% is often cited, a higher lysine:CP ratio can be used in the diet because the lysine released during normal muscle protein breakdown is conserved and recycled with greater efficiency than other amino amino acids. Ratliff et al. (2005) suggested that the total lys:CP ratio should not exceed 7.1%. Nemechek et al (2011b) found that feed efficiency was only poorer when the total lysine:CP ratio exceeded 7.35%. More research is clearly needed to continue to improve our understanding of nonessential amino acid needs of the pig.

Research needs

The increased production and economic competitiveness of crystalline amino acids has greatly enhanced research efforts and our understanding of amino acid requirements in the past 10 years. Commercial additions of L-valine and L-tryptophan to diets are now a reality. As these amino acids continue to become more cost competitive relative to soybean meal, more research is needed to increase our understanding in a few key areas:

- Methods to ensure non-essential amino acids are met when formulating to the fifth or sixth limiting amino acid.
- Increased understanding of amino acid interactions such as interactions between branched chain or large neutral amino acids when one or more are fed in excess.
- Methods to evaluate these potential interactions in least cost diet formulation packages. Should each large neutral amino acid be formulated in a ratio relative to the other large neutral amino acids?
    - Ex. Because the isoleucine:lysine ratio increases when blood cells or blood meal are included in the diet, how can the cost of increasing isoleucine be factored into the least cost formulation to properly evaluate the cost of blood products.
    - Ex. diets that contain high levels of corn protein (through corn gluten products or dried distillers grains with soluble (DDGS)) contain very high branch chain amino acid levels and low tryptophan levels. Some data indicates the requirement to tryptophan will be greatly increased in these situations; however, more research is required.
- Rapid and low cost methods to verify crystalline amino acid inclusion rates and distribution in diets. Reliance on small inclusion rate ingredients such as crystalline amino acids increases the importance of proper mixing and distribution.
- Validation and increased availability of in vitro methods to assess amino acid digestibility. Ex lysine in DDGS or other heat treated ingredients.

Conclusion

Over the past 10 years our understanding of amino acid requirements has dramatically improved. Data suggest that the lysine requirement of modern lean genotypes increases over time with continued genetic improvement for lean gain. Numerous studies have evaluated ratios of other amino acids to lysine which has provided a framework for diet formulation. As production of additional crystalline amino acids becomes economically feasible, we will not only see greater use of low-protein amino acid fortified diets, but diets fortified with greater numbers of crystalline amino acids. Our challenges for the next 10 years will be to understand conditions when and why amino requirements or ratios change and to preserve this information in the public domain.

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Table 1. SID lysine recommendations as influenced by weight

Pig weight, kg	g/kg of gain	g/Mcal ME	%[a]	g/Mcal ME	%[a]
5	19	4.17	1.40	4.20	1.40
10	19	3.99	1.34	4.01	1.34
15	19	3.82	1.28	3.83	1.28
20	19	3.66	1.22	3.66	1.23
30	20	3.35	1.12	3.36	1.13
40	20	3.08	1.03	3.10	1.04
50	20	2.83	0.95	2.89	0.97
60	20	2.62	0.88	2.70	0.91
70	20	2.43	0.81	2.55	0.85
80	20	2.27	0.76	2.41	0.81
90	20	2.14	0.72	2.29	0.77
100	20	2.04	0.68	2.18	0.73
110	20	1.97	0.66	2.08	0.70
120	20	1.93	0.65	1.98	0.66

[a]Adapted from van Heugten (2010) and Main et al. (2008a). Assumes protein deposition rate of 150 g/d from 20 to 120 kg (barrows: g/Mcal = $0.000146 \times (\text{BW, kg})^2 - 0.0377 \times (\text{BW, kg}) + 4.352$; gilts: g/Mcal == $-0.00000094 \times (\text{BW, kg})^3 + 0.000306 \times (\text{BW, kg})^2 - 0.0435 \times (\text{BW, kg}) + 4.414$).

[a]Percentage is for a diet containing 3350 kcal ME/kg (corn-soybean meal diet without added fat using NRC (1998) nutrient values.

Table 2. Suggested minimum SID amino acid ratios for growing swine[a]

Amino acid	Pig weight range, kg					
	4 to 25	25 to 40	40 to 60	60 to 80	80 to 100	100 to 130
Lysine	100	100	100	100	100	100
Threonine	62	61	61	62	63	64
Methionine	28	28	28	28	28	28
Methionine + cysteine	58	56	56	56	57	58
Tryptophan [b]	16.5	16.5	16.5	16.5	16.5	16.5
Isoleucine[c]	52	52	52	52	52	52
Valine	65	65	65	65	65	65
Arginine	42	40	38	36	34	34
Histidine	32	32	32	32	32	32
Leucine	100	100	100	100	100	100
Phenylalanine	60	60	60	60	60	60
Phenylalanine + tyrosine	94	94	94	94	94	95

[a]Adapted from Shannon and Allee, 2010 with updates by authors. Ratios are based on NRC (1998) nutrient levels for ingredients. Nutritionists should review their ingredient nutrient values relative to NRC (1998) to apply these ratios to their diets.
[b]Tryptopan:lysine ratio appears to be increased when the diet contains large excesses of large neutral amino acids (leucine, isoleucine, valine, phenylalanine, and tyrosine)
[c]Ratio is at least 60% when high levels of blood meal or cells are included in the diet. Ratio may be lower than 52% when blood cells are not included, but more research is required to verify and to determine the optimal ratio of isoleucine to leucine.

Table 3. Suggested minimum SID amino acid ratios for major amino acids for growing swine using Brazilian ingredient nutrient values to calculate ratios[a]

Amino acid	Pig weight range, kg					
	4 to 25	25 to 40	40 to 60	60 to 80	80 to 100	100 to 130
Lysine	100	100	100	100	100	100
Threonine	64	64	64	65	67	68
Methionine	28	28	28	28	28	28
Methionine + cysteine	58	56	56	57	57	58
Tryptophan [b]	17	17	17	17	17.5	17.5
Isoleucine[c]	55	55	55	55	55	55
Valine	69	69	69	69	69	69

[a]Adapted from Shannon and Allee, 2010 with updates by authors. Ratios were converted to those achieved with ingredient nutrient values of Rostagno (2005).
[b]Tryptopan:lysine ratio appears to be increased when the diet contains large excesses of large neutral amino acids (leucine, isoleucine, valine, phenylalanine, and tyrosine)
[c]Ratio is at least 60% when high levels of blood meal or cells are included in the diet. Ratio may be lower than 55% when blood cells are not included, but more research is required to verify and to determine the optimal ratio of isoleucine to leucine.

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Nursery Nutrition: Key Concepts for Economical Nursery Feeding Programs

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The key focus of nursery nutrition programs is to transition pigs from lactation where they are consuming a highly digestible liquid diet to a low cost grain soybean meal based diet. Critical components of this transition are to phase feed expensive protein and carbohydrate sources. However, these alternative protein and carbohydrate sources have dramatically increased in cost over the last few years. This has led to using lower cost alternative sources and reducing feed budgets of expensive diets. Many of these alternative sources are lower quality. Therefore, these strategies can result in disappointing performance.

A successful nursery feeding program contains several components, but the most important are to: 1) match dietary nutrient levels and ingredients with weight and age of the nursery pig; 2) maximize feed intake, because newly weaned pigs are in an extremely energy deficient state and early intake helps maintain a healthy intestine; and 3) appropriately adjust pigs (based on age, weight, health status, etc.) to lower cost diets (usually grain-soybean meal diets) as quickly as possible after weaning to reduce total feed cost. The concepts are relatively simple and can be applied in a variety of situations around the world. Detailed specifications that have been used successfully are detailed elsewhere (DeRouchey et al., 2010; Tokach et al., 2007). However, significant modifications of these diets have occurred in the last 2 years. These modifications will be the focus of this paper.

Recent research at Kansas State University has focused on further defining the amino acid requirements during the nursery phase (Nemecheck 2011). One significant finding that has changed our diet formulation strategy has been the lowering of dietary lysine levels in diets for pigs less than 15 lb or in the first 1 or 2 diets after weaning while maintaining high dietary lysine levels during the later nursery phase (Nemecheck et al. 2010). This has allowed for maintaining excellent performance level while altering the amount of specialty protein sources needed in diets for young pigs Recommendations for dietary lysine levels are listed in Table 1.

Table 1. SID lysine recommendations as influenced by weight

Pig weight, lb	g/kg of gain	g/Mcal ME	%[a]
11	19	4.17	1.40
22	19	3.99	1.34
33	19	3.82	1.28
44	19	3.66	1.22

[a]Percentage is for a diet containing 3350 kcal ME/kg (corn-soybean meal diet without added fat using NRC (1998) nutrient values.

Also, due to expense of fat sources relative to corn we have reduced or removed fat levels in nursery diets. The low feed intake of young pigs often leads nutritionists to feed high levels of fat to increase the energy density of the diet. Unfortunately, fat utilization from the diet is limited in the pig before approximately 35 days of age. Poor utilization of dietary fat is not well understood and may be due to a combination of factors including low digestibility during the initial period from changing fatty acid type compared to milk fat after weaning. Also, newly weaned pigs have limited ability to catabolize fat from body stores. However, added dietary fat is extremely important from a feed manufacturing standpoint because it helps lubricate the pellet mill die, and, thus, improves pellet quality of starter diets that contain high levels of milk products. The bottom line is that fat utilization increases with age and fat should be used strategically in the first diets after weaning as an aid in pelleting rather than as a main energy source.

Traditionally in the US, fish meal sources such as select menhaden fishmeal have provided a large portion of the specialty protein sources in nursery diets. However, in the US availability of high quality fish meal has declined and the price has become more expensive relative to other sources. Therefore, there are three main strategies being employed to eliminate fish meal from nursery pig diets. The first and with a longest history of research data is to replace the fish meal with spray dried blood meal or cells. When switching to spray dried blood meal differences in digestible amino acid profile need to be accounted for in diet formulation, especially methionine and isoleucine requirements (Table 2). Also stringent monitoring to ensure some other source of blood meal such as ring or flash dried. These products typically are more variable in quality and can have lower amino acid availability.

The second strategy is to replace all or some of the fish meal with dried porcine enteric mucosal products such as DPS 50 (Nutraflow, Sioux City IA) or PEP (Techmix, Stewart, MN) products. These products are by products of heparin collection from porcine intestine. Recent research indicates that these can be excellent replacements for fish meal in nursery pig diets (Meyers, 2011).

The final strategy is to use supplemental synthetic amino acids to minimize the amount of soybean meal in nursery pig diets. Synthetic lysine, threonine, and methionine are widely available for supplementation in swine diets. In addition, synthetic tryptophan, valine and isoleucine are available and may be used in nursery pig diets depending on the protein sources available. Reducing the amount of fishmeal in diets for 15 to 25 lb pigs and increasing the amount of synthetic amino acids have been shown to increase growth rate in nursery pigs (Nemecheck et al. 2011). This method requires setting minimum ratios for amino acids relative to lysine (Table 2.)

Table 2. Suggested minimum SID amino acid ratios for growing swine[a]

	Pig weight range
Amino acid	10 to 55 lb
Lysine	100
Threonine	62
Methionine	28
Methionine + cysteine	58
Tryptophan	16.5
Isoleucine	52
Valine	65

[a]Adapted from Shannon and Allee, 2010 with updates by authors. Ratios are based on NRC (1998) nutrient levels for ingredients.

Dried distillers grains with solubles (DDGS) also have been used successfully in nursery pig performance (Stein and Shurson, 2009). Certainly as with the growing pig the quality of the source can have an influence on the dietary value. Also, the fermentation process leaves mycotoxins unchanged. Thus, with the removal of starch during fermentation and the concentration of other components of the corn kernel by approximately 3x the mycotoxin level in the DDGS will be approximately 3x of the corn used in the fermentation process. However, the amino acid profile of DDGS can be used successfully to reduce the need for specialty protein sources like fish meal. In addition the price of DDGS in the Midwest US is approximately 80 to 85% of corn price while having the additional amino acids and higher phosphorus availability. We have used moderate levels of DDGS successfully in the first diets after weaning (10 to 20%) and in concentrations as high as 40% in the later nursery diets to reduce feed cost, without negative effects on growth performance.

The other main ingredient in nursery diets that has increased dramatically in price in the last few years is lactose source. Procuring high quality lactose sources at an economical cost continues to be a challenge. The high lactase enzyme levels at birth and high digestibility of lactose make crystalline lactose or one of several lactose sources (dried whey, deproteinized whey, whey permeate, etc.) an excellent carbohydrate source for young pigs. As long as the diet contains a basal level of lactose, several other carbohydrate sources can be used for the remainder of the diet while achieving acceptable performance. However, the lactose source along with complementary carbohydrate sources is probably one of the most important dietary factors for influencing variability in nursery performance in the period immediately after weaning. Unfortunately, there are few indicators of lactose source quality. Traditionally, the best way to ensure lactose quality is to specify human edible grades of lactose sources and minimize sources to those that have demonstrated consistent quality.

Traditionally, we have used diets in pellet form in the immediate period after weaning. Diets fed in meal form in the immediate period after weaning have been shown to increase feed intake and reduce removal rates (Groesbeck et al. 2009). However, due to the increases in feed cost and increased economic value of feeding diets in pellet form we are observing a move to feeding pellets in other phases during the nursery. As with finishing pigs a critical factor for maintaining the performance benefits is the quality of the pellet with a minimum amount of fines or without an excess of heat that denatures the specialty protein and carbohydrate sources.

Over the last 10 years once significant change in US swine production has been an increase in weaning age and has lead us to reexamine creep feeding practices (Sulabo, 2009).

Things we have learned:

a. The main effect of creep feeding is to help get pigs started on feed in the early period after weaning in the nursery. There is not going to be any benefit in increasing weaning weight or reduction in weight loss of the sows.
b. Based on our research we would recommend the following creep feeding protocol:
    i. Use the round creep feeder with the reservoir that has a cover
    ii. Put the creep feeders in 3 to 4 d prior to weaning
    iii. Fill 1 time with 2 lb per feeder
    iv. Use the first phase nursery diet and not simple diets
    v. Ensure feeders are adequately cleaned between use

Also the reduction in weaning age, this has led to a reduction of the amount of diet fed to pigs less than 15 lb and consolidation of the traditional two diet program for pigs fed less than 15 lb in to a single diet phase. Various versions of the single phase nursery diet and examples of diet formulations using the concepts outlined in this paper are available at www.ksuswine.org.

Although there has been evolution in weaning ages, changes in production practices and increases in ingredient costs in the last few years the objective of nursery feeding programs remain unchanged. This objective is to transition the pig as rapidly as possible from a liquid to dry diet with the staging of specialty protein and carbohydrate sources to economical grain and soybean meal based diets.

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Economic Evaluation of Feed Per Unit of Gain: Is Lower Always Better?

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As feed costs have increased over the last several years, feed per unit of gain (feed efficiency) has increased in economic value relative to other production parameters. Since feed cost typically represents the largest proportion of the costs of pork production, feed efficacy is typically assumed to be an indirect indicator of profitability. This reasoning suggests that less use of a resource (feed) leading to a lowering the numerator or increasing gain (increasing the denominator) will improve feed per unit of gain. The next step in the logic is that improved feed efficiency will then be an indirect indicator of increased profitability. Thus, the fundamental question is lower feed per unit of gain always better?

The first step is to understand how feed efficiency is calculated. As the name feed per unit of gain implies it is a simple ratio of feed divided by amount of gain or a ratio of Average Daily Feed Intake / Average Daily Gain (F/G=ADFI/ADG). Feed is typically fairly straight forward to account for in the equation. Usually, the difficulty comes in the definition of gain. The accepted way to calculate close out feed efficiency is:

$$\frac{\text{Total feed delivered}}{(\text{Weight sold} - \text{Weight started})}$$

Note that dead pig weight is not included in the calculation.

In nutrition research most trial designs that characterize nutrient requirements are designed over relatively small biologically ranges that would not be expected to have a different response in mortality rates across nutritional treatments. One accepted practice in research experiments is to include dead pig weight in the calculation of feed efficiency. For example a market weight pig that dies of torsion in an amino acid experiment. In a 10 or 20 pig pen if the weight gain of this pig is not accounted for in the feed per unit of gain calculation the gain will be under accounted due to a death that is not treatment related. Accounting for the dead pig weight will result in a more precise measure of feed per unit of gain and indicator of the economic differences across treatments. On a group close out though accounting for dead pig weight will lead to a better feed per unit of gain. However, the improvement is not directly linked to improved economic outcome. Thus, the first answer to the question is lower always better is that it depends on how feed per unit of gain is calculated and what context the information is going to be used. In the case of close out information excluding dead pig weight and leading to a higher feed per unit of gain is the appropriate indicator to correlate with economic performance. In the case of the research experiment including dead pig weight will be a more precise indicator of economic performance of the nutritional treatment.

Another factor to consider is that as the pig grows and matures the feed required per unit of gain becomes poorer. For example in a benchmark comparison across farms feed efficiency a higher feed per unit of gain may actually be better. The higher feed per unit of gain may be the result starting and ending weights differing significantly across the comparison. For example when comparing Farm A with a finisher feed efficiency of 2.90 to farm B with a 2.84 feed efficiency, Farm A may actually have lower feed wastage. Farm A has a start weight of 25 kg (55 lb) and market weight of 127.7 kg (280 lb) compared to Farm B with a start weight of (23.7 kg (50 lb) and a market weight of 113.6 kg (250 lb). Thus, although Farm B has a lower feed efficiency the starting and ending weights are also lower. Adjusting for the increased body weights from farm B results in a feed per unit of gain of 2.73 if pigs were started and sold at the same weight as Farm B. Thus, this is a case where when first evaluating the data, the 2.90 feed efficiency may actually be better than the 2.84 feed efficiency.

The next step is to link the biologic efficiency of feed per unit gain with an economic measure by adding feed cost and expressing feed per unit of gain as feed cost per unit of gain. Thus, we have converted a biologic number into and economic indicator where the sensitivity of different economic scenarios can be modeled.

Formula:

Feed cost per unit of gain = Feed cost / unit of gain

Example: 250 kg Feed x $ 0.25 per kg / 100 kg gain = $62.50/100 kg gain or $.6250/kg gain

Alternative formula:

Feed cost per unit of gain = feed cost per unit x feed per unit gain

Example: $ 0.25 per kg feed x 2.5 F/G = $0.625 per kg/gain

Evaluation of the economics of feed per unit of gain can then be broken into different scenarios to rapidly assess the impact of a given feed efficiency impact on economic performance.

Scenario 1 – Lower feed cost, no difference in feed efficiency

Examples include: Reduce cost of feed ingredients or removal of ineffective additives.

Reduce the numerator cost without change in feed efficiency will lower feed cost per unit of gain. This is an example were no change in feed per unit of gain is better. The lower cost is a direct indicator of economic performance since there is no impact on any of the biologic parameters.

Scenario 2 – Higher feed cost, lower feed efficiency or the reverse of lower feed cost with higher feed efficiency resulting in no impact on ADG.

Example: Higher dietary energy with added fat in finishing pigs

Finisher pigs – Feed efficiency is lower as the result of a constant caloric intake with lower feed intake and no change in growth rate. This is a case where it depends on the cost of added fat to determine if the lower feed efficiency is a better economic return.

As an example based on the diet costs and expected feed per unit of gain the higher energy diet results in the higher feed cost per unit of gain. In this scenario lower feed per unit of gain fails to result in better economic performance.

Scenario 2 Economic Evaluation of Increased Dietary Caloric Density in Grower Pigs

	Dietary Caloric Density	
Item	Low	High
Feed Cost per Kg, $	0.28	0.31
Expected FG	3.50	3.30
Cost per kg gain, $	0.98	1.02

Therefore, the economics of this scenario result depend on accurate values for the expected feed per unit of gain (FG) and the assumption that changing energy density will not impact other parameters such growth rate and carcass composition. In this case, the lower feed per unit of gain results in higher feed cost per unit of gain. Under different economic conditions where the cost of added fat is lower the increased diet cost may be offset by the improvement in feed per unit of gain and actually lower feed cost per unit of gain. Thus, determination if lower is better from an economic perspective depends on the cost of added dietary energy.

Scenario 3 – Higher feed cost, lower feed efficiency and higher ADG or the reverse of lower feed cost with higher feed efficiency and lower ADG.

Example: Higher dietary energy with added fat in grower pigs

Grower Pigs - Feed efficiency is lower based on no change in feed intake, resulting in a higher caloric intake that drives a higher growth rate.

This becomes a more complicated scenario to evaluate economically. The value of ADG varies depending on type of production system (fixed weight or fixed time) and the ability to achieve optimum market weight. In order to evaluate the economics we use a calculation of income over feed cost in fixed time or growing pig space short systems. This calculation assumes that fixed amount of time is spent in the growing pig period so the all other costs beside feed and revenue are fixed and equivalent. Thus, the comparison of the difference across scenarios will be an indicator in differences in profitability. For the fixed weight comparison facility cost becomes another variable cost and thus facility cost is added to the cost side of the equation.

Scenario 3 Economic Evaluation of Increased Dietary Caloric Density in Grower Pigs

	Dietary Caloric Density	
Item	Low	High
Feed Cost per Kg, $	0.29	0.32
Expected FG	2.20	2.07
Cost per kg gain, $	0.638	0.66
<u>Fixed Time</u>		
Days	20	20
kg Gain	17	18
Feed, $	10.84	11.92
Revenue, $	13.84	14.65
Income over Feed, $	2.99	2.73
<u>Fixed Weight</u>		
Days	21	20
kg Gain	18	18
Feed, $	11.48	11.92
Facility, $	2.10	2.00
Revenue, $	14.65	14.65
Income over Feed & Facility	1.07	0.73

Certainly, there are other scenarios to consider when changing feed per unit of gain and growth rate which will alter rates of protein and fat deposition. These alterations can in turn influence carcass yield and composition. Also, the question on how to calculate revenue numbers will be highly dependent on the payment scheme for the purchaser or if an integrated operation the value of products produced.

Therefore, the clear objective is to develop models and sensitivity based on performance to indirectly predict an influence on profitability. Feed per unit of gain provides a gross indicator interference levels but more sophisticated modeling is needed to determine if lower is better.

Some general observations about and the correlation between feed per unit and gain and economic performance include two categories where marginal cost is minimal to obtain improvements and cases where a more detailed analysis is needed.

Examples of minimal marginal cost include:

Reduced feed wastage – consider that a feeder providing for two 25 pig pens will deliver almost $12,000 of feed per year per feeder the return for replacing feeders can easily be less than 1 year. Another way to look at things is that in a 40,000 sow farrow to finish system wasting one hand full (0.5 kg or 1.1 lb) per feeder results in about $1,200 of wasted feed per day. This is a major reason we have focused considerable effort on evaluating feeder adjustment and feeder design strategies over the last several years.

Grain particle size reduction – Research data indicates that reductions in grain particle size improve digestibility down to at least 300 to 400 microns. The accepted standard is an improvement of in feed per unit of gain of 1.2% for each 100 micron reduction. Thus, each reduction by 100 microns can be worth $0.75 to $1.00 per pig. Other considerations such as feed mill throughput and feed handling characteristics. However, over the last several years many of our progressive producers have figured out how to handle feed with 500 to 600 micron average grain compared to 750 to 800 micron averages in the past.

Examples where marginal cost needs to be evaluated:

Genetics – Again we need good predictive models of what will be the relative difference and trade off with improvements in feed efficiency compared to other traits. Growth rate, feed efficiency and carcass composition are relatively easy to predict impact. More difficult traits that will impact profitability include meat quality and survivability. Our general observation though is that investment in genetics to improve feed per unit of gain is a high return investment.

Nutrient Requirements - In general in the past era of relatively low corn and feed cost, feeding for maximum biologic performance was almost always a direct indicator of profitability in the US. However, as illustrated with dietary energy this is not the case anymore. Biologic optimum does not always correlate with economic optimum. This certainly is not news to our colleagues around the world have had to deal with higher feed costs on a continuous basis but is now the reality in the US.

Feed processing techniques such as pelleting and extrusion – This is an example where trials done with good pellet quality show great response but with poorer pellet quality there is little improvement in feed efficiency. Pelleting has other advantage such as allowing use of a lower particle size and still maintain flow ability. Unfortunately, this is a case where the results depend on the location. Also, these are the classic example where these processes require the expenditure of capital up front. Thus, different entities may come up with different economic answers based on the same biologic data.

Therefore, in answer to the question from an economic perspective is lower always better? As with most things the correct answer is “it depends”.

Porcine Circovirus Type 2 Vaccination: Effect on Growth Performance and Carcass Characteristics

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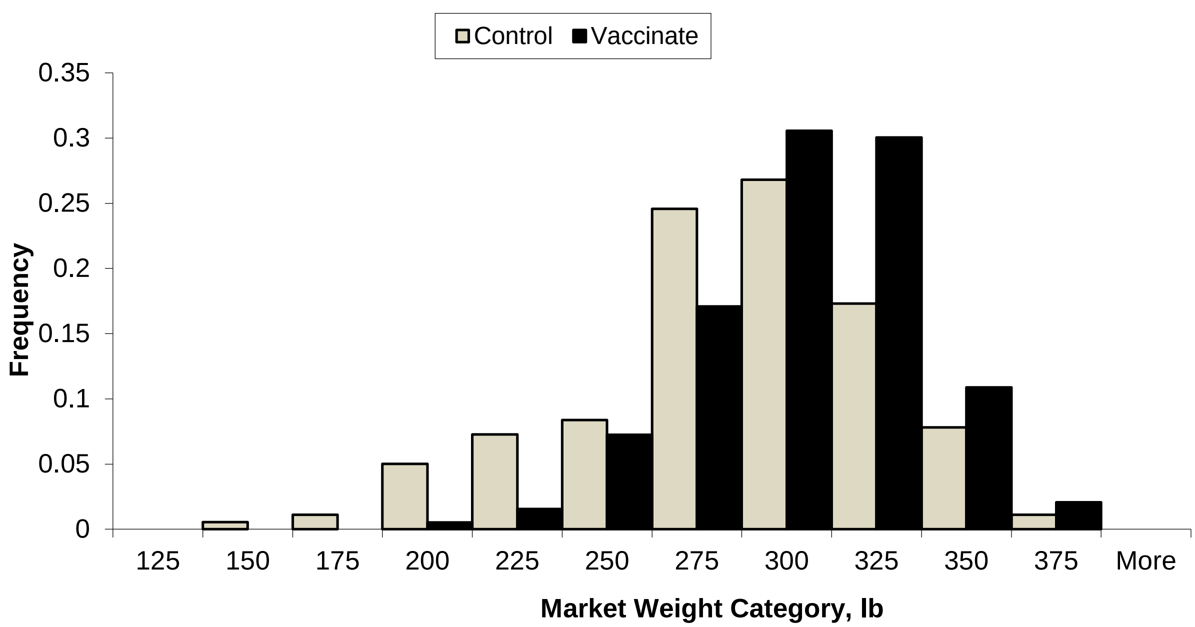
Several studies have been conducted to evaluate the efficacy of PCV2 vaccines by using various criteria, including mortality rate, viremia, and co-infections. However, relatively little data has been available on the production impact of PCV2 vaccination on growth rate, feed efficiency and carcass characteristics Over the last several years it has been apparent that the production benefits of PCV2 vaccination are a major economic driver of the impacts of PCV2 vaccine.

In addition to the significant influence of PCV2 vaccination on decreasing mortality rate and increasing mean growth rate the most significant finding was the shifting of the growth curve for the whole population of vaccinated pigs (Figure 1. Horlen et al. 2008). This indicated all pigs in a PCV2 infected group were affected by to some degree by the PCV2 infection. This study was conducted in a herd with readily apparent clinical signs of PCV2 disease during the finisher phase.

Figure 1. Distribution of final pig weight of survivors (Adapted from Horlen et al., 2008)



Additional, work has confirmed the influence of PCV2 vaccination on ADG with indications of an influence on feed efficiency (Table 1. Jacela et al., 2011). Growth-rate differences between nonvaccinated and vaccinated pigs peaked between the day 14 and 42 on test (Figure 2). The lower ADG in pigs without PCV2 vaccination preceded the observed rise in mortality, and the greatest difference in cumulative mortality between vaccinated and nonvaccinated pigs was noted between day 42 and 84 on test (Figure 3.).

Table 1. Effect of PCV2 vaccination on growth performance (Adapted from Jacela et al., 2011)

	PCV2 vaccination			
Item	No	Yes	SEM	*P* <
Exp. 1*				
Day 0 to 96				
Mortality (%)	5.9	3.2	1.0	0.05
On test BW, lb	79.0	77.0	0.6	0.02
ADG, lb	2.03	2.10	0.01	< .001
ADFI, lb	5.19	5.29	0.01	0.03
F:G	2.56	2.52	0.01	0.05
Off test BW, lb	259.9	262.8	1.1	0.07
Exp. 2†				
Day 0 to 105				
Mortality (%)	9.3	3.0	1.1	<0.001
On test BW, lb	57.6	56.5	1.1	0.28
ADG, lb	1.95	2.03	0.011	<0.001
ADFI, lb	4.95	5.03	0.046	0.28
F:G	2.53	2.48	0.023	0.14
Off test BW, lb	263.1	269.4	1.7	0.004

* A total of 1291 pigs were randomly assigned to two treatments (Vaccinated and Control) within barrows and gilts. Commercial PCV2 vaccine (Circumvent; Intervet Inc, Millsboro, Delaware; 2 mL per dose) was administered to Vaccinated pigs at 9 and 11 weeks of age.

† A total of 1253 pigs (initially 5.5 kg) were assigned randomly by nursery pen average weight before administration of the first vaccine dose Commercial PCV2 vaccine. (Circumvent; Intervet Inc, Millsboro, Delaware; 2 mL per dose) administered at 5 and 7 weeks of age to the Vaccinated treatment group (41 and 27 days before being placed on test in the finisher)..

Figure 2. Average daily gain by days in the finisher (Adapted from Jacela et al., 2011 Exp 2).

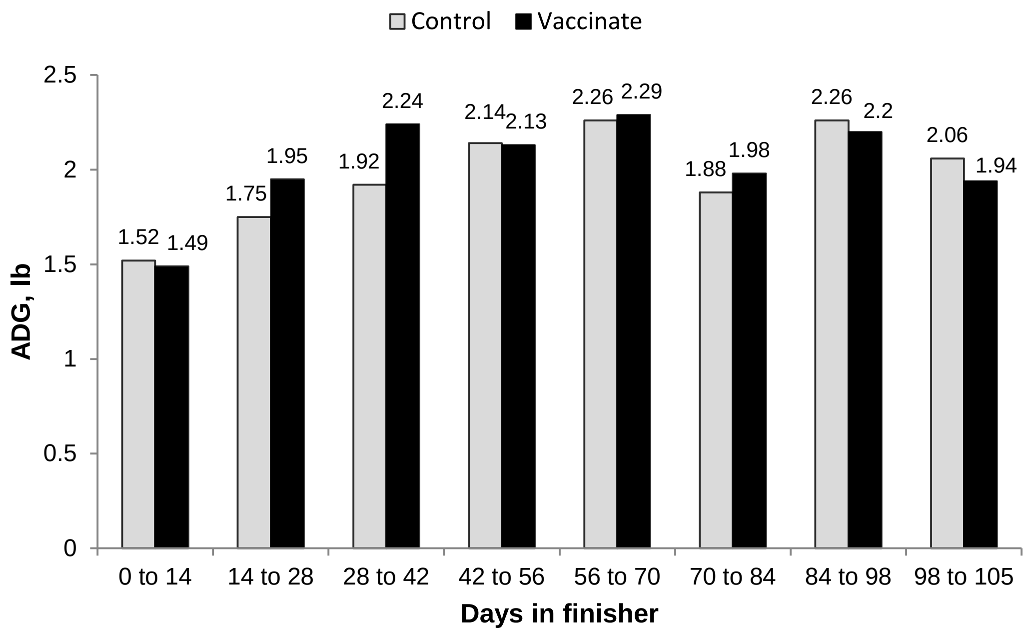


Figure 3. Cumulative mortality rate by day on test (Adapted from Jacela et al., 2011 Exp 2).

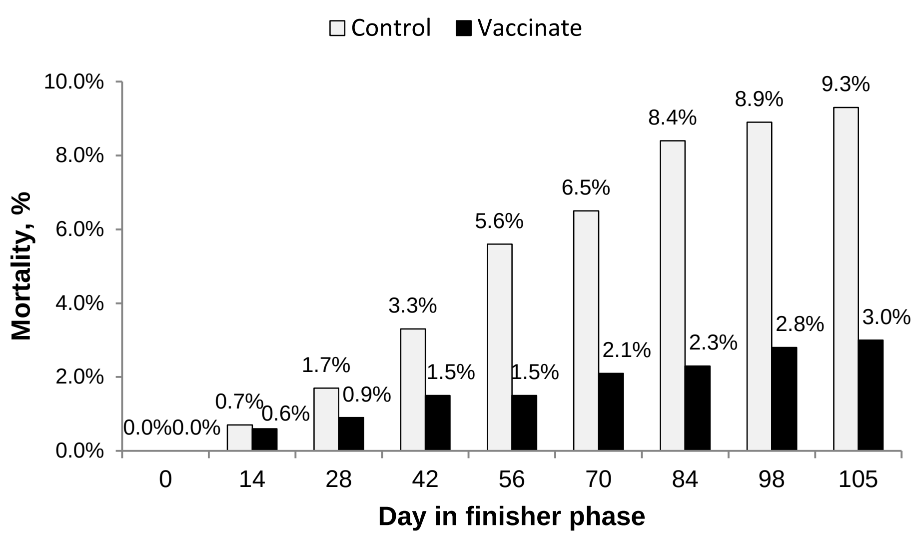


Table 2. Carcass characteristics (Adapted from Jacela et al., 2011 Exp 2).

	PCV2 vaccination			
Item	No	Yes	SEM	*P* <
Carcass weight, lb	200.4	203.8	1.1	0.03
Yield, %	75.6	76.1	0.25	0.22
Backfat, in	0.63	0.64	0.008	0.45
Adj Backfat, in*	0.64	0.64	0.007	0.92
Loin, in	2.43	2.48	0.019	0.07
Adj Loin, in*	2.45	2.47	0.017	0.40
Lean, %	56.4	56.3	0.16	0.64
Adj Lean, %*	56.3	356	0.16	0.95

* Values were adjusted to a common carcass weight by using carcass weight as a covariate in the model.

The PCV2 vaccination in Exp. 2 from the study of Jacela et al. (2011) increased carcass weight as expected due to increased ADG. Note we were unable to detect impacts on carcass yield, back fat, and lean percentage. However, there was a tendency for increased loin depth in vaccinated pigs. However, when adjusting loin depth to a common BW, there was no difference in loin depth. Thus, the increased loin depth was simply due to having bigger pigs at the end of the study.

In another field trial in a high health status boar multiplication farm without infection from PRRSv or detected infection with *Mycoplasm hyopneumoniae* improvements in growth rate due to vaccination were detected (Table 3. Potter et al., 2011) The mortality from weaning to off test for the unvaccinated pigs was 7.0% while the vaccinated pig mortality rate was 6.8%. Active PCV2b infection without readily apparent clinical disease was documented during this trial. Another interesting observation from this study was that the increase in growth rate from vaccination was greater in the Duroc based genotype compared to the Pietran based genotype. The magnitude of the difference in growth rate improvement from vaccination was over 4 times greater in the Duroc based line compared to the Pietran based line.

Back fat and loin depth were measured using real time ultrasound at 130 d after weaning. There was little impact on back fat and a tendency for increased loin depth in vaccinated pigs. However, similar to the results of Jacela et al (2011) when adjusting for differences in BW there was no evidence that vaccination impacted carcass measurements.

Table 3. Means and standard errors for growth rate and carcass traits for control and PCV2 vaccinated pigs of different genotype (Adapted from Potter et al., 2012).

	Genotype						
	A×A		B×B		*P* <		
Item	No	Yes	No	Yes	Genetic × Vaccine	Genetic	Vaccine
No. of pigs	62	55	55	54	--	--	
ADG, lb	1.20±.027[a]	1.32±.028[b]	1.33±.03[b]	1.36±.030[b]	0.04	0.003	<0.001
Weight, d 130 lb	200.4±4.5[a]	220.2±4.6[b]	220.2±4.9[b]	225.3±5.0[b]	0.05	0.003	<0.001
Carcass traits, mm							
Backfat [4]	11.4±0.34	12.0±0.35	10.6±0.37	10.8±0.38	0.46	0.02	0.13
Loin[5]	59.2±0.87	62.2±0.91	68.8±0.95	69.6±0.96	0.32	<0.001	<0.001
Adj. backfat[6]	12.2±0.33	12.1±0.33	10.7±0.34	10.7±0.35	0.79	<0.01	0.62
Adj. loin[7]	62.3±0.69	62.6±0.69	69.2±0.71	69.2±0.72	0.82	<0.001	0.29

[1] Results are reported as least squares means±SEM.

[2] Genetic designations were A×A (Duroc line) and B×B (synthetic White Pietrain line) and their crosses. Data from crosses not shown

[3] A circovirus vaccine (Circumvent PCV; Intervet/Schering-Plough Animal Health, Millsboro, DE) was administered intramuscularly (2 mL per dose) to vaccinated pigs at 21 and 35 d of age.

[4] Backfat and loin depth depth was adjusted to a common average off-test weight.

[ab] Within a row, means without a common superscript letter differ (*P* < 0.05).

Table 4. Effect of PCV2 vaccination on growth performance during 28 day periods during the grower and finisher phase (Adapted from Shelton et al., 2012).

	Grower				Finisher			
	PCV2 Vaccination‡				PCV2 Vaccination‡			
Item	No	Yes	SE	*P* <	No	Yes	SE	*P* <
Barrows*								
Initial weight, lb	83.4	87.9	1.6	0.06	215.0	215.6	2.2	0.86
ADG, lb	1.83	2.07	0.04	0.001	2.14	2.06	0.02	0.02
ADFI, lb	4.18	4.63	0.07	0.001	6.94	6.65	0.09	0.04
F/G	2.30	2.24	0.03	0.08	3.25	3.24	0.04	0.80
Final weight, lb	140.0	146.2	2.0	0.04	260.3	259.1	2.0	0.68
Removal, %	12.0	0.7	--	--	0.5	0.7	--	--
Gilts†								
Initial weight, lb	82.7	86.3	1.4	0.08	220.6	227.9	1.5	0.002
ADG, lb	1.62	1.86	0.02	0.001	1.77	1.82	0.03	0.24
ADFI, lb	3.56	3.97	0.00	0.001	5.87	5.81	0.07	0.60
F/G	2.21	2.14	0.04	0.001	3.33	3.20	0.03	0.02
Final weight, lb	130.6	138.4	0.0	0.09	270.4	279.1	1.6	0.001
Removal, %	6.4	0.2	--	--	0.2	0.4	--	--

‡Vaccination for porcine circo virus (PCV2-Circumvent) was administered at one week post placement into the wean to finish facility and again three weeks later.
*Initially, 1,002 barrows (PIC 337 X 1050) were used in two 28-day trials (1 grower and 1 finisher) with 20 pen replications per treatment.
¥ The feed efficiency for the vaccinated pigs was adjusted for the differences in initial and final body weight using methods outlined in the Kansas Swine Nutrition Guide.
†Initially, 1,008 gilts (PIC 337 X 1050) were used in two 28-day trials (1 grower and 1 finisher) with 20 replications per treatment.

In a large scale commercial study designed to evaluate the interaction between dietary lysine requirements and PCV2 vaccination the improvements in growth rate during the grower phase were again confirmed with little impact of growth rate in the finisher phase when pigs had recovered and developed immunity from natural exposure (Table 4). In the barrows, it appeared that there may have even been some compensatory gain in the unvaccinated pigs. Also, when adjusting for the differences in BW due to the growth rate influences there does not appear to be an impact of vaccination on feed efficiency. Note that BW gain and pig days of removed pigs was used to calculate ADG and feed efficiency in this research trial as is standard practice in experiments designed to evaluate nutritional requirements. This is in contrast to calculations of feed efficiency in most commercial record keeping systems that do not consider the BW gain of the removed pigs in the calculation of feed efficiency. Thus, in commercial situations when comparing closeouts with differences in mortality rate the higher mortality group will have a poorer feed efficiency just due to the elevated mortality. In our research trial we accounted for the BW gain of the removed and dead pigs since we wanted to evaluate the efficiency of gain without the differences in mortality and removal rate. Although, we clearly showed a difference in mortality rate prior to and during the grower phase, mortality adds variability that makes it difficult to interpret the impacts of disease on feed efficiency.

In the dietery lysine requirement portion of this study we showed advantages to increasing the SID Lys:ME ratio that are similar to those reported by Shelton et al. (2008, 2009) and greater in magnitude than those previously reported in the same facility by Main et al. (2008). There were no differences in optimal SID Lys:ME ratio between PCV2 vaccinates and non-vaccinates; however, the increased growth from increased ADFI during the grower phase when clinical disease was most apparent suggests that PCV2 vaccinates have an increased daily Lys requirement on a g/d basis compared with non-vaccinates from 90 to 130 lb.

Also, as in other studies there was little influence of PCV2 vaccination on carcass traits (data not shown). However, this study did indicate a significant reduction in feed intake and growth rate due to PCV2 vaccination during the nursery phase (Table 5).

Table 5. Effect of PCV2 vaccination on carcass measurements after the finisher phase (Adapted from Shelton et al., 2012).

	Barrow PCV2 Vaccination‡				Gilt PCV2 Vaccination‡			
Item	No	Yes	SE	*P* <	No	Yes	SE	*P* <
Live weight, lb	260.3	259.1	2.0	0.68	270.4	279.1	1.6	0.001
Yield, %	74.4	74.8	0.3	0.25	75.7	75.7	0.3	0.87
Backfat, in	0.76	0.78	0.01	0.24	0.61	0.65	0.01	0.03
Loin Depth, in	2.26	2.23	0.03	0.52	2.44	2.48	0.04	0.35
Lean, %	54.0	53.6	0.2	0.29	56.2	56.4	0.3	0.71

‡Vaccination for porcine circo virus (PCV2, Circumvent) was administered at one week post placement into the wean to finish facility and again three weeks later. Each number represents means from 20 pens of pigs.

Although the improvements in removal and growth rate were readily apparent in the results from the large scale commercial study of Shelton et al. (2012) there was a negative impact on growth rate and feed efficiency during the nursery phase (Table 6.). This effect was most pronounced during the immediate period after the administration of the second vaccine dose.

Table 6. Effect of PCV2 vaccination on growth performance in the period immediately after administration at d 0 and 22 after weaning (Adapted from Shelton et al., 2012).

Item	PCV2 Vaccination‡ No	PCV2 Vaccination‡ Yes	SE	*P* <
Initial wt, lb	12.5	12.5	0.26	0.99
d 0 to 15[2]				
ADG, lb	0.59	0.59	0.024	0.93
ADFI, lb	0.87	0.84	0.029	0.46
F:G	1.48	1.43	0.012	0.15
d 15 to 29[3]				
ADG, lb	0.95	0.90	0.014	0.02
ADFI, lb	1.47	1.39	0.025	0.04
F:G	1.54	1.54	0.004	0.87

[1]A total of 2,571 barrows and gilts (PIC 337 × 1050) were double stocked into a wean-to-finish barn and observed for 50 d to determine the effects of PCV2 vaccine on growth performance.
[2]The first PCV2 vaccine (Circumvent) was given on d 1 of this study to the selected pens of pigs.
[3]The second PCV2 vaccine was given on d 22 of the study to the randomly assigned pens of pigs.

Therefore, based on the results of this study (Shelton et al., 2012) and due to field reports of PCV2 vaccination we initiated a study to evaluate the impacts of nursery vaccination programs on growth performance during the nursery phase (Potter et al., 2012). In this study we evaluated the effects of vaccination for circovirus and *M. hyo* on nursery pig performance in a 3 × 2 factorial arrangement. Main effects included circovirus vaccine and *M. hyo* vaccine. The circovirus vaccine treatments were: (1) no circovirus vaccine (non-circovirus-vaccinated control); (2) a 2-dose vaccine, Circumvent PCV; and (3) a 1-dose vaccine, Ingelvac CircoFLEX (Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO. The *M. hyo* vaccine treatments were: (1) no *M. hyo* vaccine (non-*M. hyo*-vaccinated control); and (2) a 2-dose vaccine, RespiSure (Pfizer Animal Health, New York, NY). All vaccines were administered as separate intramuscular injections according to label directions (Circumvent PCV: 2 mL per dose given on d 0 and 21; CircoFLEX: 1 mL per dose given on d 0; RespiSure: 2 mL per dose given on d 0 and 21).

There were no significant interactions between the effect of vaccination for circovirus and *M. hyo* vaccination (*P* > 0.68). There was a tendency for pigs vaccinated with *M. hyo* vaccine to be 0.9 lb/pig lighter at d 35 after weaning compared to those not vaccinated with *M. hyo* vaccine. The circovirus vaccination reduced growth rate and pig weight at d 35 after weaning (Table 7). However, this effect was product dependent with the two dose Circumvent vaccine accounting for all of the impact. Also, note that the impact on growth rate was a direct result of decreases in nursery feed intake with little impact on nursery feed efficiency. The impact was most pronounced after the second vaccine dose. Therefore, these data suggest that vaccination with the second dose around the time of weaning should be avoided if using the two dose product. Although there were no interactions between the circovirus and *M. hyo* vaccine impact on growth performance the negative effects in Circumvent vaccinated pigs were additive. Pigs vaccinated with Circumvent and Respisure grew 0.07 lb per day slower and were 2.4 lb lighter a d 35 after weaning compared to those pigs that did not have any vaccination during the nursery phase (Figure 4.). Therefore, the potential negative impacts of vaccine usage during the nursery phase need to be balanced against potential disease control efficacy during the finishing phase. Also, when evaluating low nursery feed intake and growth rate, vaccination schedule should be evaluated as a risk factor.

Table 7. Means for the effect of circovirus vaccination on nursery pig growth performance, feed intake, and feed efficiency (Adapted from Potter 2012).

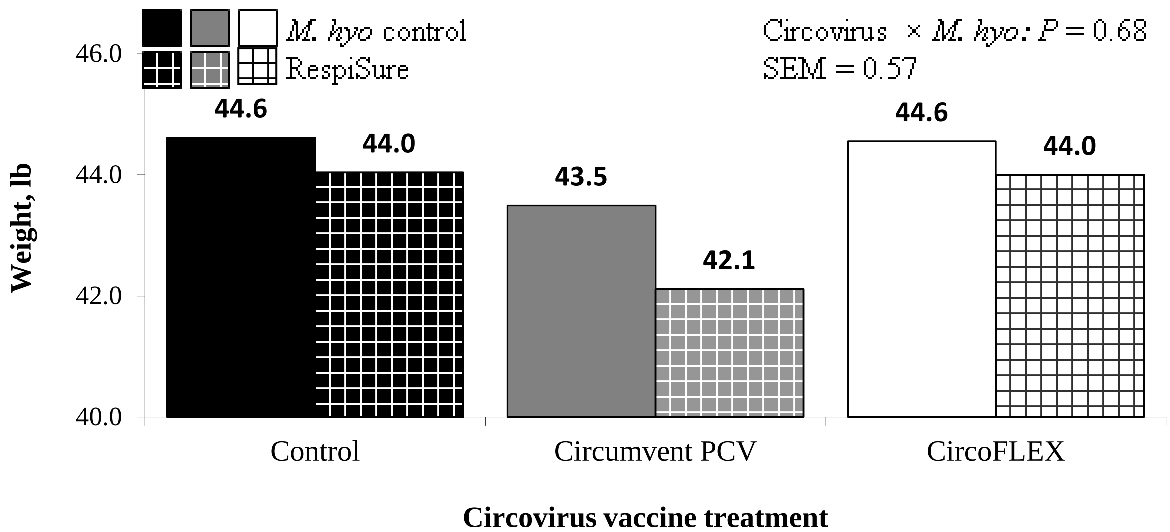
	Circovirus vaccine treatment[2]				Probability,
Item	Control	Circumvent PCV	CircoFLEX	SEM	*P* <
d 0 to 8					
ADG, lb	0.28	0.26	0.29	0.02	0.26
ADFI, lb	0.28ab	0.26a	0.29b	0.01	0.05
F:G	1.01	1.01	1.02	0.03	0.94
d 21 to 29					
ADG, g	1.07a	0.95b	1.10a	0.03	< 0.001
ADFI, g	1.70b	1.57b	1.72a	0.04	< 0.001
G:F	1.59	1.64	1.56	0.01	0.08
d 0 to 35					
ADG, g	0.89a	0.85b	0.90a	0.02	0.02
ADFI, g	1.29a	1.23b	1.31a	0.03	0.003
G:F	1.45	1.45	1.47	0.01	0.30
d 35	44.2a	42.9b	44.2a	1.2	0.01

[1]A total of 360 barrows were used in a 35-d study. There were 5 pigs per pen and 24 pens per circovirus vaccine treatment.

[2]Circovirus vaccine treatments were: (1) Control: non-circovirus-vaccinated pigs; (2) Circumvent PCV: 2 mL per dose of Circumvent PCV (Intervet/Schering-Plough Animal Health, Millsboro, DE) injected intramuscularly on d 0 and 21; and (3) CircoFLEX: 1 mL Ingelvac CircoFLEX (Boehringer Ingelheim Vetmedica, Inc, St. Joseph, MO) injected intramuscularly on d 0.

[ab] Within a row, means without a common superscript differ ($P < 0.05$).

Figure 4. Effect of PCV2 vaccination and mycoplasma vaccination in high health pigs at the end of the nursery phase (d 35 after weaning).



In conclusion, results from our studies indicate the following effects of PCV2 vaccination on production traits:

-Reduced mortality
-Increased growth rate
-Impact on growth rate is not limited to clinically affected pigs
-PCV2 impact on growth rate precedes impact on removal and mortality rates
-Inconsistent effect on feed efficiency
-No effect on carcass traits
-Product dependent decrease on nursery feed intake and growth rate

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Weaning Management

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Without a doubt the swine industry has restructured dramatically in the last decade. Multiple site production has made a large impact on herd health and how we manage flows of weaned pigs. In addition we have seen weaning ages creep up to an average of 19 to 21 days of age. However, despite these changes, several key management practices remain. These focus around the three primary needs of the weaned pig: feed, water and air (environment).

Procedures needed to be implemented before pigs arrive include setting ventilation controls to allow for the room to dry after washing and disinfection. The room should also be warmed up before pigs arrive and supplemental heat sources should be in place and functioning. Mat feeding for the first 3 days in the nursery is encouraged. While average daily gain and feed efficiency are not improved with mat feeding, percentage of pig removals has been shown to significantly decrease when pigs are mat fed for 3 days. Mat feeding for longer periods tends to result in poorer feed efficiency (Potter et al., 2010).

All waterers should be functioning and adjusted to the proper height. Waterers should be set at shoulder height for the smaller pigs in the pen. Cup waterers have been used successfully and reduce water wastage compared to nipple waterers. Using wet/dry feeders as a water source in the nursery phase will result in decreased growth performance of weanling pigs (Nitikanchana et al. 2011). Regardless of whether the first diet after weaning is bagged or in bulk, the feed gate in all feeders should be closed before the first pellets are placed in them. The feed gate then is opened so that a small amount of feed is visible in the feed pan. Placing pelleted feed into empty feeders with the gate open will result in large amounts of feed wastage.

If all of the proper preparatory procedures are performed, the pigs can be left to rest for approximately 36 hours after weaning. Pigs should be observed to ensure that they have found the water source and are beginning to develop feeding behavior. The objective during the period immediately after weaning is to only make minor environmental adjustments and let the pigs rest and acclimate.

By 36 hours after placement, most pigs will have found water and started to exhibit feeding behavior. However, this is a critical time period to identify pigs that have not eaten or are becoming dehydrated. This may involve hand feeding a few pellets or using a gruel administered with a syringe; as little as 20 to 30 g of feed will provide enough energy to keep the pig from starving. It is critical for small pigs with low body fat reserves to have a readily available energy source. We believe that teaching feeding behavior to a small number of pigs is essential. The identification of candidate pigs for teaching feeding behavior is a high priority during the first few days after weaning. This is an area of pig management that requires astute observation of pig behavior. Pigs that are eating well will begin to have round abdomens, whereas pigs that have not begun to eat will be gaunt. With proper management of the nursery, the number of pigs requiring extra attention will be limited to 2 to 4%.

As for feeding programs, the key concepts are relatively simple and can be applied in a variety of situations around the world. We adhere to three key concepts when formulating diets for the weaned pig. First, the economics of today's swine industry dictate that we must adjust pigs to the simplest and relatively lowest cost diets (i.e., grain and soybean meal) as quickly as possible after weaning. Second, we must remember that the newly weaned pig is in an extremely energy dependent stage of growth and that maximizing feed (energy) intake is essential. Third we must remember the digestive physiology of the pig and formulate the initial diets with highly digestible ingredients that complement the pattern of digestive enzymes secreted pre- weaning.

For many years we have focused our attention on complex and expensive Segregated Early Weaning (SEW) and Transition diets typically fed from weaning to 7 kg bodyweight. These diets have relied on relatively high amounts of specialty protein sources such as spray-dried animal plasma, spray-dried whey, fish meal, and blood meal. The reason for such high amounts of these ingredients were first to stimulate feed intake, but secondly to provide enough lysine and other amino acids to minimize the use of soybean meal to no more than 12% of the diet. Typical lysine concentrations of these SEW and Transition diets were 1.7 and 1.65% total lysine, respectively (1.56 and 1.50% standardized ileal digestible lysine). However, these diets were formulated for pigs that are approximately 3 to 6 days younger and at least a kilogram lighter than pigs weaned today on many farms. Therefore our research has focused on re-evaluating lysine and other amino acids requirements and testing new specialty protein sources for weaned pigs. The results of these studies has led us back to our phase 1 diet (Table 1) to replace SEW and Transition diets.

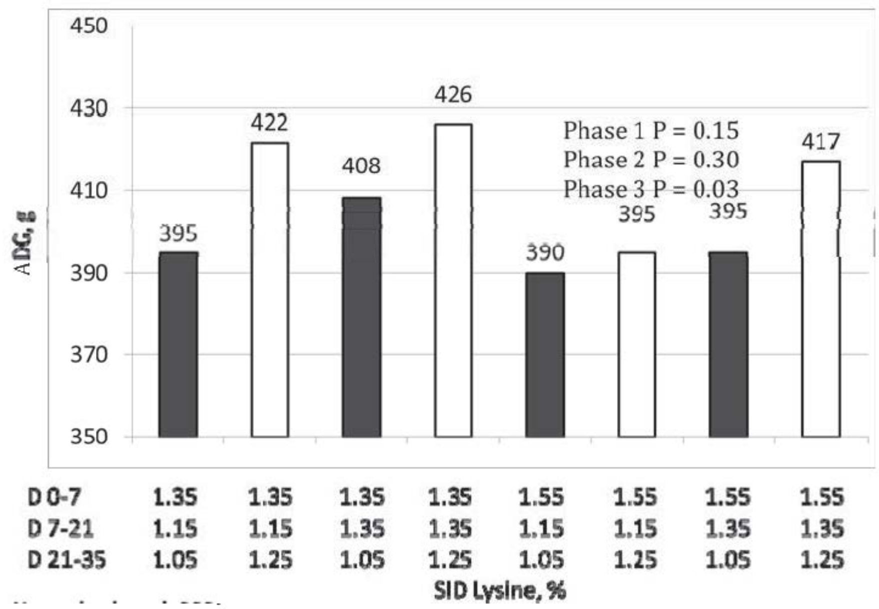
Table 1. Suggested diet options for 6 to 7 kg weanling pigs

		Guaranteed Potency in Complete Diet Select one option	
Ingredients, %	1	2	3
Spray-dried whey[1]	25.0	25.0	25.0
Spray–dried animal plasma[2]	4.0	4.0	5.0
Spray-dried blood meal or cells[3]	1.25	---	1.25
DPS 50 or PEP NS[4]	3.0	---	---
PEP 2+[5]	---	3.75	---
Corn Minimum	38.0	38.0	38.0
Maximum	42.0	42.0	42.0
Soybean meal (46.5%)	17.0	17.0	17.0
Corn distiller grains with solubles[6]	5.0	5.0	5.0
Fat[7]	3.0	3.0	3.0
Monocalcium P (21% P)	0.85	0.90	0.85
Limestone (38% Ca)	0.85	0.80	0.85
L-Lycine HCl	0.20	0.225	0.20
DL-Methionine	0.125	0.125	0.125
L-Threonine	0.075	0.075	0.05
Salt	0.30	0.30	0.30
Zinc oxide	0.39	0.39	0.39
Acidifier	0.20	0.20	0.20

[1] Edible grade or equivalent
[2] American Proteins, DuCoa, Merricks, or North Central Processors.
[3] American Proteins, California Spray Dry, or Merricks.
[4] Nutro-Flo (DPS-50) or Tech-Mix (PEP-NS).
[5] Tech-Mix (PEP 2+).
[6] High quality DDGS with over 26% CP and over 8% fat.
[7] Soybean oil or choice white grease.

We know that dietary lysine is extremely important in weanling pig diets, yet what if we could reduce lysine levels early and maintain them in later diets, would the pig compensate? To answer this question we conducted a study looking at lysine concentrations in a three phase diet program (Nemecheck et al., 2010). Within each of the three phases pigs were fed either a low of typical lysine level in the diet. This resulted in a total of 8 dietary lysine treatments. In phase 1, pigs fed the low lysine diet were no different in average daily gain but poorer in feed efficiency than those fed the typical lysine diet. The same response was observed in phase 2 as well. However in phase 3 there was a lysine response for average daily gain where pigs fed the high lysine diets had greater average daily gain than those fed the low lysine diets (Figure 1).

Figure 1. Effects of dietary lysine level in phase 1, 2, and 3 on weanling pig average daily gain[1].



[1]Nemecheck et al. 2010

The ramification of this study is that we can slightly lower lysine levels in our first diet and as long as lysine is adequate in phase 3, performance will not be affected compared to pigs fed typical, high lysine diets. The second ramification is that with the ability to formulate the first diet fed post weaning to a low lysine level (again maintaining adequate lysine levels in phase 3), we don't need as much of the specialty protein sources, hence saving diet cost.

The second are of research was to evaluate new protein sources for weanling pigs. This arose ironically because of the BP oil spill in the Gulf of Mexico in summer 2010. As a result select menhaden fish meal became in short supply and its price doubled. In addition, blood meal/cell availability decreased and people were left looking for alternatives to fish meal. It appears two options exist: crystalline amino acids and intestinal peptide protein sources. To examine the use of crystalline amino acids, we conducted a series of experiments. First was to determine the standardized ileal digestible lysine level for pigs in our nursery. Then we used crystalline amino acids to successfully replace fish meal in the diet. Next we established ratios of other amino acids to lysine, and finally tested the concept by evaluating several different protein sources with high or low inclusion of crystalline amino acids. Results of these studies suggest that, when formulated properly, crystalline amino acids can replace some of the more expensive specialty protein sources in the diet such as fish meal.

A second alternative to fish meal is the use of intestinal derived protein sources such as DPS 50 (Nutra-flo, Sioux City, IA), and Peptone products (PEP 2+, Pep-NS, Tech-Mix, Stewart, MN.). Either of these three protein sources has been shown to be effective replacements for fish meal in phase 1 and 2 starter diets (Jones et al., 2010, Myers et al., 2010).

The phase 3 diet is the lowest cost diet in the 3 phase nursery-feeding program. However, because consumption of the phase 3 diet is the greatest, it usually accounts for 50% of the total feed cost from weaning to 23 kg. Typically, 20 to 23 kg of feed is budgeted for pigs during this phase. Thus, cost of this diet is critical to minimize total feed cost while maximizing performance in the nursery. Specialty ingredients, such as spray-dried blood meal, fishmeal or dried whey, are cost prohibitive, because research has failed to indicate improved growth performance from feeding such ingredients in phase 3 (Tokach et al., 2003). This diet should resemble a grow-finish diet, which in most cases will be a simple grain-soybean meal diet. The digestive capacity of the pig by this weight is such that these ingredients are unwarranted; including them will increase feed cost/pig.

In conclusion, the basic concepts and management practices for feeding older-weaned pigs are not different than those for younger weaning ages. Intense management of newly weaned pigs to get them started on feed as soon as possible is critical to the success of the nutritional program. Ultimately, producers who have high nursery feed intake, follow strict nursery feed budgets, use high-quality ingredients will also maximize profitability.

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