991 Swine Day Report

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The decade of the 1990's will continue to bring changes to the swine industry. New biotechnology products that enhance lean tissue growth and help control disease will dramatically influence pork production in the '90's. Producers must keep informed of new opportunities to make their operations more efficient and competitive.

The goal of our swine research program is to provide information that will aid Missouri producers in improving productivity or reducing costs. This 1991 Swine Research Report is one of the many efforts of the Department of Animal Sciences, University of Missouri, to assist Missouri swine producers. We have attempted to briefly inform you of what we have done, what we have found and how you may use these results in your operation. We welcome your suggestions on how we can do a better job in communicating our research results.

The swine industry in Missouri is a significant contributor to the state's economy. Our swine group at MU is dedicated to serving this very economically important Missouri swine industry by providing effective teaching, research and extension programs.

Listed within this report are those directly supporting our swine program this past year. We greatly appreciate this support.

Sincerely,

Gary L. Allee

Gary L. Allee
Unit Leader
Animal Science

GLA/ell

ACKNOWLEDGEMENT

Through the Mr. Frederick B. Miller Trust, the Department of Animal Sciences in the College of Agriculture is able to enrich the program of research, scholarships and development of livestock.

This publication of research topics concluded or in progress and/or lectures focus on current technology of interest to the Pork Producers in the industry. Presentation of research results will continue on an annual basis.

Participants from off-campus and from other facilities assemble with resident staff from the University of Missouri Animal Science faculty to review, discuss and update technology related to industry opportunities and problem evaluation. This new knowledge base complements existing technology and provides Missouri producers the competitive advantage or opportunity to improve resource utilization for maximum production efficiency and profitability.

COMPANIES AND ORGANIZATIONS CURRENTLY SUPPORTING UM SWINE RESEARCH - 1991

Addison Biological Laboratory, Inc., Fayette, MO
Archer-Daniel-Midland, Mexico, MO
Biokyowa, Inc., Chesterfield & Cape Girardeau, MO
Bio Techniques Laboratories, Inc., Redmond, WA
Diamond V. Mills, Inc., Cedar Rapids, IA
Estrogenix, Inc., Boulder, CO
Farmland Industries, Inc., Kansas City, MO
Intervet American, Inc., Millsboro, DE
Hoechst-Roussel AgriVet Company, Somerville, NJ
Hoffmann-La Roche, Inc., Nutley, NJ
Lilly Research Laboratories, Greenfield, IN
Merck and Company, Inc., Rahway, NJ and Fulton, MO
MFA Incorporated, Columbia, MO
Missouri Department of Agriculture Marketing Division, Jefferson City, MO
Missouri Pork Producers Association, Columbia, MO
Missouri Soybean Merchandising Council, Jefferson City, MO
Monsanto Company, St. Louis, MO
National Pork Producers Council, Des Moines, IA
Pfizer, Inc., Lee's Summit, MO
Pitman Moore, Inc., Terra Haute, IN
Protein Technology International, Ralston Purina, St. Louis, MO
RELEFE Corporation, Russelville, AR
Roussel-Uclaf, Paris, France
United States Department of Agriculture, Washington, DC
Wilson Food Corporation, Marshall, MO
The Upjohn Company, Kalamazoo, MI

SPECIAL CONTRIBUTORS TO 1991 UMC SWINE DAY

Pork Chop Meal	--	Pfizer, Incorporated
Swine Day Proceedings and Activities	--	Diamond V. Mills, Inc. A. L. Laboratories, Inc. Frederick B. Miller Endowment Moorman Manufacturing Company MFA Incorporated
Guest Speaker	--	Frederick B. Miller Endowment Eli Lilly and Company

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Trends in Missouri Hog Production and How to Reverse Them

by

V. James Rhodes
UM Department of Agricultural Economics

There has been much discussion of why Missouri hog production has fallen so greatly in the 1980s. A good case can be made for such causes as the farm financial crisis and the several droughts. Other people feel that too many producers have been squeezed out because they have stayed with obsolete facilities and techniques. It is certainly true that lots of us have room for improvements and there is a real need for more education. There is some evidence that lenders are too tight with really good producers who want to borrow on income potential without possessing plenty of collateral. I won't try to assess the relative importance of each of those four causes of farm crisis, droughts, capital and poor management. Together, they are very important. After studying structural changes nationally, I would point at two other factors unique to Missouri hog production that help to explain the decline in hog production.

The first factor is size of producer. All across the country for the past 30 years or more the share of hog production and sales has been falling for farms selling less than 1,000 hogs and pigs per year. For example, the share of U.S. sales of the smaller farms has declined from 66% in 1978 to 44% in 1987, which is a fall of more than 2% a year. At that rate the share of the smaller farms would be down to about 13% by the year 2000. Missouri has had and still has a larger than national average share of smaller units. Missouri's smaller hog farms (< 1,000 head sales) had a 76% share of Missouri sales in 1978 (10% above the national share) and a 56% share in 1987 (12% above the national share). We are not immune to national forces, so I would predict that we will continue to lose smaller hog farms. In the 1987 Census of the 10 leading hog states only two others, besides Missouri, had a majority of their hog sales from farms selling less than 1,000 head.

This table illustrates what has been happening to Missouri hog and pig production.

Percentage Change in Hogs & Pigs Sold 1978 to 1987

	Farms Selling < 1000 head	Farms Selling 1000 & more	All Size Farms
West N. Central Region	-30.9%	81.2%	3.7%
Missouri	-47.0	40.3	-25.4

Source: U.S. Ag Censuses. The WNC Region is the tier of states of MO & KS north to Canada.

Note that the WNC Region had a small gain in sales of hogs and pigs between the 1978 and 1987 Censuses while we in MO lost ¼ of our production. There are 3 statistical reasons: (1) a larger loss of sales (47 vs 31%) in the smaller units (2) a larger share of output in smaller farms in MO and (3) a smaller increase (40% vs 81%) in sales of the larger farms. While the relatively small size of Missouri's hog producers is part of the problem, the much smaller growth by the larger units in MO compared to the WNC indicates that other factors -- such as financial stress or drought or tight capital or inadequate management -- were also important.

Here's how the 1978-87 changes look in absolute numbers. Missouri's sales of hogs and pigs by units selling less than 1000 head went down 2,225,000 head while the sales by its larger units went up 610,000 for a net loss of 1,615,000 head -- a larger loss than any other state.

Second, there was one other difference in Missouri's hog industry that helps to explain its large losses. We have had a very large production of feeder pigs. For example, feeder pigs were 29% of our hogs and pigs sales in 1978 compared to 22% for the WNC Region of which we are a part. Missouri feeder pig production has downsized very rapidly in the 80s so that our feeder pigs sales were only 23% of all sales in 1987 which was much closer to the 21% in 1987 for the WNC. Therefore, of our net loss of 1.64 million head sales of hogs and pigs from 1978 to 1987, .77 million or 47% was a loss in feeder pig sales.

These numbers are not reassuring. We can expect further decline in the 2.7 million head output of our smaller units as some expand beyond 1000 head and some quit production. Clearly, our larger units will have to grow greatly just to maintain our current production of hogs.

What I call the super-producers, the big firms like Cargill, Carroll Foods, Murphy, National Farms, and Tyson, have attracted much interest and some controversy. Their growth has been impressive. I'm convinced that they will continue to grow and that there are another dozen or more firms that will grow into this super-producer category in the next 5 years.

The available evidence suggests that the growth of these super-producers relative to conventional operations is based on sound economics. These operators are expanding because their good management makes good profits. Note that each is a corporate entity whose management skills and vision are not limited to a single person and whose continued growth would not be ended by any specific person's retirement. Therefore, I expect the super-producers to keep on growing indefinitely in size and number. It is possible that some big changes in diseases or in the ability to use lagoons or in public attitudes could stop this trend, but those appear unlikely.

Having argued that the super-producers are coming, my most important points are these two:

(1) you conventional producers should not panic, and
(2) Missouri should not try to keep super-producers out of the state.

There should be no panic because a fraction -- one-fourth or one-third -- of you can match the efficiencies of the super-producers, so you can compete indefinitely with them. But what about the rest of you? There is no reason that most of you can not raise your efficiency to a competitive level if you set your mind to it. I grant that some producers are not young enough that you want to invest more capital or even to change your ways. Even you should not throw in the towel right now. There has been good money in hogs. Stay in as long as there is. I suggest some of these profits stem from conventional producers quitting because they felt they would not be able to compete. Granted, it is smart to quit when you are losing money and see no prospects of making it back. However, I worry that some producers have quit prematurely because they anticipated that they would soon be run over by the super-producers. My message is that the super-producers still produce less than 10% of the hogs. During the rest of this century the biggest share of the production -- and of your competition -- will be from other Midwest producers like you. Know your costs and if you can compete, stay the course.

My second point is that we should not try to keep super-producers out of Missouri. Their production means jobs and income in the state -- and their hogs would help to keep the infrastructure of suppliers and packing plants that all hog producers need. But won't they drive out Missouri producers? That pressure is not related to the location of the super-producers. Yes, the expansion of producers -- big or little -- will pressure the less efficient producers. But it is a national market for hogs and pork. Expansion of a Murphy will pressure your hog prices no more if he's your neighbor than if he's in Iowa or North Carolina. Iowa ran out Premium Standard; our Mercer County is getting the economic benefits of Premium Standard. While Premium Standard's impact on hogs prices is not enough to be measurable, rest assured that if there were a perceptible impact Iowa producers would feel it just as much as if Premium Standard were located at Ames.

Missouri's milder climate gives it some advantages over the northern Corn Belt in producing pigs. If our pork industry is to reverse its decline, two things need to happen: many of you producers need to increase your efficiencies and your output, and some super-producers need to become sizable producers in Missouri. Both of those are possible.

THE NORTH CAROLINA PORK INDUSTRY

Charles M. Stanislaw
North Carolina State University

Swine production is a major part of the North Carolina agricultural economy. Among farm commodities, only tobacco and poultry exceed it in importance. Gross income from hog sales is approximately $500 million (1989). The annual pig crop is estimated to be approximately 4.5 million head. Currently, North Carolina ranks seventh among all states in swine production.

North Carolina has received much national attention because of its high concentration of large scale swine operations. Over one hundred twenty farms have sow herds of 500 or greater. Also, approximately thirty farms have sow herds of 1000 or more. Four of the nations five largest swine producers operate in North Carolina. Murphy Farms of Rose Hill, NC is the largest with a reported hog sales of over $100 million (1988). Carroll's Foods, Prestage Farms, Tyson's of Carolina, Cargill, Worthington Farms and Purvis Farms are other large scale swine production operations.

The annual pig crop in North Carolina has grown steadily since 1981 and agricultural forecasters believe that this trend will continue. Many industry observers from other states have asked about the factors that have been responsible for this sustained growth. I have been asked to discuss with you some of these factors, specifically those that have been identified for me as being of specific interest to you in Missouri.

1. University, State Department and pork producers cooperative efforts to develop the swine industry.

The most visible, and perhaps the most successful, cooperative project of these groups is the Demonstration Farm at Rocky Mount. However, the major impact of these groups results from the large staff devoted to swine in both the Animal Science Department of the University and in the Department of Agriculture. In Extension Swine Husbandry there are six state specialists, two area specialists, the Central Testing Station manager and two On-farm Swine Performance Testing Program technicians. The Agricultural Extension Service also supports three Area Specialized Swine Agents. Major support for the swine industry also comes from faculty in the departments of Agricultural Engineering, Agricultural Economics and Entomology. North Carolina State University also has a very active swine research program with approximately twelve faculty members conducting research in a new, state-of-the-art 300 sow research and teaching facility.

The North Carolina Department of Agriculture is heavily involved in regulatory and marketing activities, but also supplies strong support in analytical services, such as feed testing, lagoon effluent analysis and diagnostic procedures. Also, the Soil Conservation Service is very active in lagoon design and layout. Each of these agencies has its programs which are fully supported and promoted by the others. This provides a broad base of support for the industry.

The producers have made great contributions in the area of legislative support. This has come both from the fact that they, collectively, have generated considerable local political support of these services, and from the fact that several prominent producers have been and are now members of the General Assembly.

2. Financing the swine industry.

The annual net cash flow, even in well managed swine operations, can fluctuate severely between positive and negative, even though the operation can be quite profitable over time. This characteristic can place considerable stress on financing new units or expansion of existing ones, especially in specialized swine operations with no alternate source of income. Lending agencies require potential borrowers to show considerable equity in order to qualify for loans because of this. This equity usually takes the form of financial reserves, or management expertise as evidenced by financial success in existing business ventures. This places a special hardship on young swine producers, since enthusiasm, intelligence and devotion per se are poor collateral. A partnership with an established producer, such as a father-son partnership, or with some other interested individual who provides a financial reserve often are arranged as a form of financing.

Production contracts can be used to accomplish the same objective. These are widely used in North Carolina, especially since many lending agencies now require a contract arrangement to protect the loan. In essence, these contracts serve the same purpose as crop insurance that protects the farmer from the financial burden of a crop failure. Contract production of swine is still an emotional issue among producers in many areas, but it is generally accepted in North Carolina for what it actually is: an alternate form of financing.

3. Building design.

One major impact on swine building design in North Carolina has been the fact that North Carolina was not a major livestock producing state. Consequently, farmers who wished to enter or expand swine production had to build new facilities, rather than be tempted to remodel old cow barns, milking parlors or horse stables. Thus, houses built for swine were designed for swine "from the ground up". Another major impact on swine building design was the rapid evolution from in-house pit storage of waste to frequent flushing (hourly) and pit recharge (weekly flushing), made possible by a winter climate mild enough to support anaerobic lagoons. A third significant factor was the availability of high quality (hand finished) concrete slats manufactured within the state. All these factors contributed to the rapid changes that have occurred in swine building design in North Carolina. It really is not much of an exaggeration to state that swine production went from total dirt to total confinement in 15 years (1965-1980). This is definitely true with the sow herds.

4. Swine Demonstration Farm

The North Carolina Swine Demonstration Center at the Upper Coastal Plain Research Station, Rocky Mount, was established in 1965. It was redesigned and expanded to a 90 sow unit in 1972, again redesigned and expanded to a 126 sow unit in 1978, and renovated and expanded to a 144 sow herd in 1988. These renovations and production system changes were made to enable the Demonstration Center to

serve more effectively as an up-to-date, state-of-the-art complete demonstrational swine unit that operates within a total program of Extension recommended facilities, practices and management. It is a cooperative effort of the North Carolina Department of Agriculture, the North Carolina Agricultural Research Service and the North Carolina Agricultural Extension Service. It is guided by an advisory board composed of NCSU and NCDA administration personnel, extension swine specialists, county agents and swine producers.

Specific objectives of the Demonstration Center are:

1. Demonstrate the latest technology in swine production and explore new ideas in facilities and materials handling systems. This would include phases of environmental control as well as waste management.

2. Utilize labor-saving practices wherever and whenever possible.

3. Maximize profit through the use of least-cost rations and other related management practices.

4. Demonstrate recommended practices relating to breeding systems, selection pressures and herd health programs.

5. Maintain and analyze detailed management records in order to adjust demonstrated techniques and develop recommendations.

6. Serve as a training center for special techniques or short courses.

The Swine Development Center has been a very effective extension teaching aid within the confines of these stated objectives. It has been used both informally on a one-to-one basis and formally on a classroom or laboratory type basis.

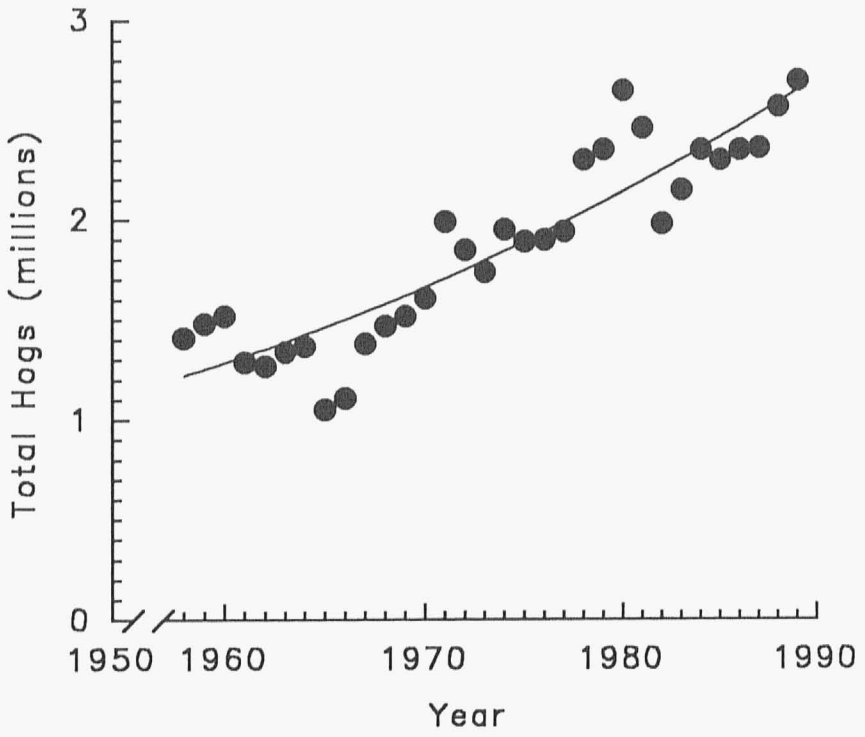
Personally, as I reflect back over the years that I have worked with the Center, I believe its greatest asset is that it is a total Extension program on display on a scale large enough to be relevant to the majority of the swine producers. Every aspect of swine production - buildings and facilities, waste handling and utilization , breeding and selection, nutrition and feeding, health, routine animal management, everything - is meshed into a production program operated to maximize profit. Further, the results are documented and available to the public. Nowhere else do we have this available.

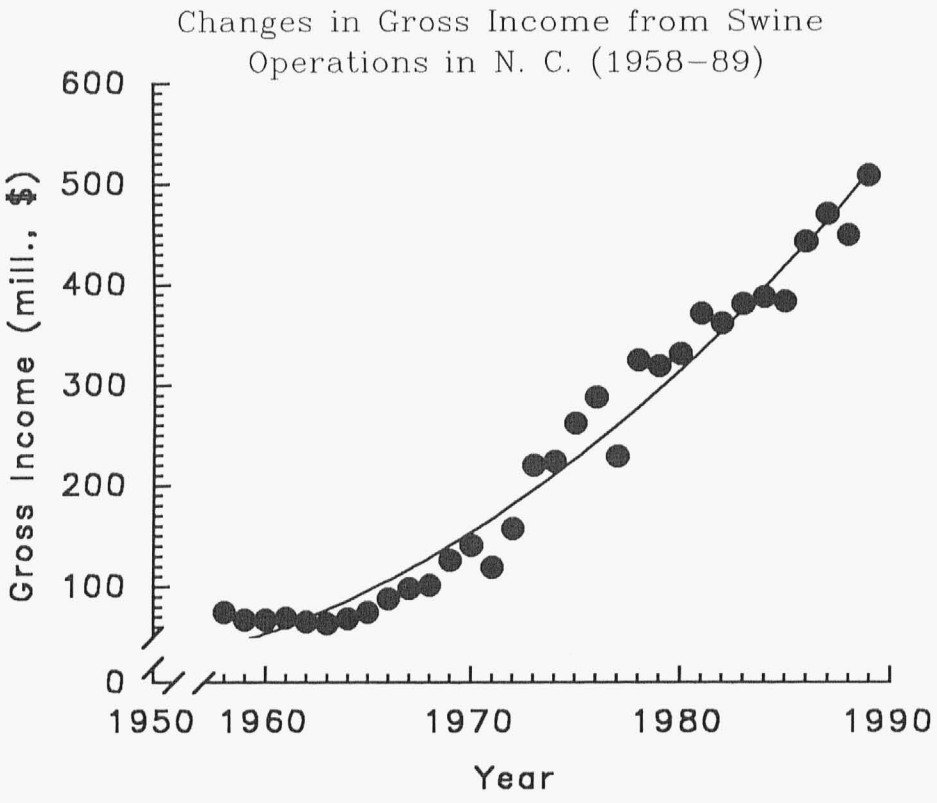
5. The future of swine production in North Carolina.

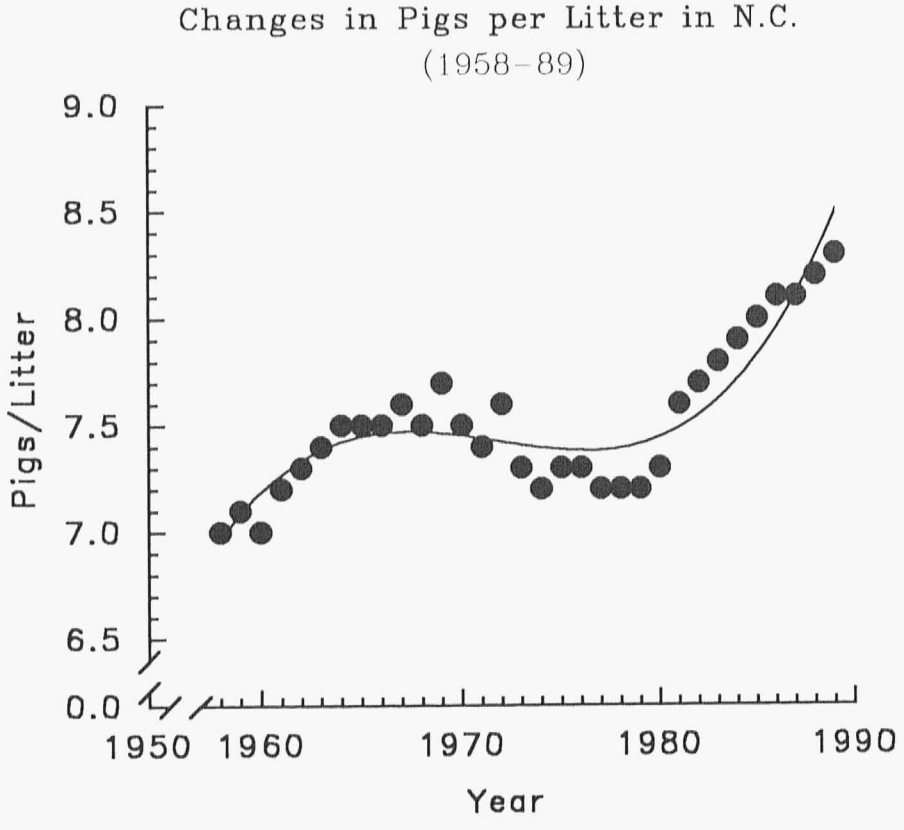
As stated earlier, forecasters predict that swine production will continue to expand in North Carolina. Most of the factors that have promoted the growth of the industry in the past will continue: favorable climate, competitive facility cost, close proximity to high population centers and sufficient and easily accessible markets and processing centers. However, growing urbanization has started to compete with the swine industry in some areas. This will undoubtedly eliminate the swine industry from some areas, such as along the Atlantic coast and around major population centers. Regulations with respect to specific nutrient loading rates on lagoon effluent receiving land are conceivable and will, in effect, place a live animal limit on land area.

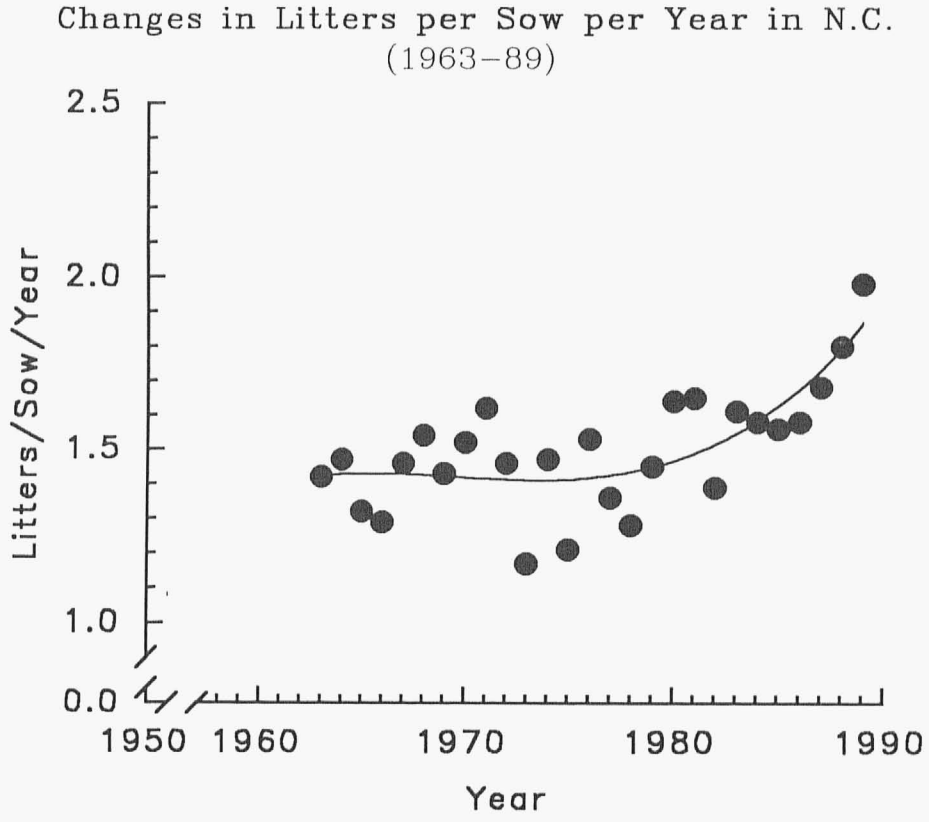
Still, swine producers are rapidly developing a high level of sophistication in fiscal, production and personnel management. The philosophy that swine producers are business people who operate with business principles will enable the swine industry to continue to grow in North Carolina.

Changes in Total Number of Hogs in N.C.
(1958-89)




Changes in Gross Income from Swine Operations in N. C. (1958–89)
Gross Income (mill., $)
600
500
400
300
200
100
0
1950
1960
1970
1980
1990
Year


Changes in Pigs per Litter in N.C.
(1958-89)
9.0
8.5
8.0
7.5
7.0
6.5
0.0
Pigs/Litter
1950
1960
1970
1980
1990
Year


Changes in Litters per Sow per Year in N.C.
(1963-89)
Litters/Sow/Year
2.5
2.0
1.5
1.0
0.0
1950
1960
1970
1980
1990
Year

EFFECT OF RECEIVING DIET ANTIBIOTIC ON SUBSEQUENT HEALTH AND PERFORMANCE OF THE PURCHASED COMMINGLED FEEDER PIG

G. W. JESSE

SUMMARY

During a six-week study (Summer 1989), 144 purchased feeder pigs were used to compare the effects of providing an antibiotic in the receiving diet for the first 28 days on performance. Treatments compared included no antibiotic versus including CSP250 or neomycin or neoterramycin. Average daily gain and feed efficiency during the medication period (first 28 days) and for the entire study favored ($P<.05$) the CSP250 and neoterramycin pigs. The neomycin fed pigs were faster gaining than the controls during the first 28 days; however, ADG for the 42-day study and feed conversion were not different ($P>.05$) from the controls.

INTRODUCTION

During the summer of 1988, purchased feeder pigs provided either CSP250, neomycin or neoterramycin during the first 28 days after arrival at the finishing facility gained 21.6% faster ($P<.05$) during the medication period than those that were not fed an antibiotic. However, ADG for the entire 98-day, growing-finishing period was not different by treatment.

The objectives of this study, which represents a follow-up of the summer 1988 trial, were twofold; first, to compare the health and performance of purchased feeder pigs fed a corn-soy diet with or without an antibiotic for the first 28 days. Secondly, to compare the health and performance of purchased feeder pigs fed one of three different antibiotics (CSP250, Neomycin, Neoterramycin) for the first 28 days of the growing-finishing period. These three antibiotics were chosen since they either have different modes of action or are known to be effective for a specific disease. The sulfa containing drug (CSP250) was selected since it is known to be effective at treating atrophic rhinitis infected pigs. Neomycin is a drug which works primarily in the gut; hence, it was selected to fight enteric problems. Neoterramycin was chosen as a drug that should be effective at combatting both respiratory and enteric diseases since it acts systemically.

PROCEDURES

On June 27, 1989 one hundred and forty-four feeder pigs averaging 43.2 lbs were purchased via the Alton Sales Company at Alton, MO. These pigs were from six different farms of origin. The experimental design, shown in table 1, was a randomized

complete block with the treatments being various feed-grade antibiotics.

TABLE 1. EXPERIMENTAL DESIGN

Treatment	No. Pigs	No. Pens
Control	36	6
CSP250	36	6
Neomycin	36	6
Neoterramycin	36	6

Level of feed grade medication was as follows:
CSP250 = 250g/ton via a 10 lb premix.
Neomycin = 200g of neomycin sulfate which provided 140g of neomycin/ton; provided via 2 lb of Neomix AG100.
Neoterramycin = 100g of oxytetracycline plus 100g of neomycin sulfate/ton via 10 lb of Neoterramycin 10-10.

The pigs for this study were selected on Monday evening, June 26 upon their arrival at the barn and penned according to owner. On Tuesday afternoon the pigs were eartagged, individually weighed and given an ivermectin injection. Dietary treatment was determined at this time and designated by the use of four different colors of ear tags. All pigs were fasted (no feed or water) during their time at the feeder pig market.

On Tuesday evening, after 24 to 30 hrs at the market, the pigs were transported approximately 350 miles before delivery to the University of Missouri Southwest Center at Mt. Vernon. Arrival at the test facility was approximately 6:00 a.m. on Wednesday.

The test facility was an open-front barn that included 30 pens of identical design. The floor and the pen dividers were solid concrete and the back wall opened to allow for natural ventilation. Each 5' x 15' pen was equipped with one nipple waterer and a one-hole Smidley self feeder. A thermostatically-controlled overhead sprinkler system was available for cooling the pigs when the temperature exceeded 80 degrees F.

Upon arrival the pigs were weighed and assigned at random, within sex and previously determined dietary treatment to pen. The original intent was for each pen to include three barrows and three gilts; however, due to unequal numbers of barrows and gilts, only replicates one through five contained equal representation of sex by pen. Replicate six included 19 barrows and 5 gilts.

All pigs were fed a 15% crude protein corn-soybean meal receiving diet in meal form for the first 28 days. As shown in table 1, four receiving diets were compared which included a

control diet (no antibiotic) and three diets with an antibiotic. Antibiotics compared included CSP250, neomycin and neoterramycin. All antibiotics were included at a level recommended by the manufacturer (see footnote of table 1). On day 1 all pigs were dewormed using dichlorvos.

On day 28 all pigs were switched to a non-medicated, 14% crude protein corn-soybean meal diet which was fed for the final two weeks of the six week study.

Pig weights and feed consumption by pen were determined every 14 days. The data were compared by analysis of variance as a randomized complete block with pen being the experimental unit. Treatment means were separated using Fisher's Least Significant Difference.

RESULTS AND DISCUSSION

As shown in table 2, the control pigs were slower gaining ($P<.05$) than all three antibiotic-fed pigs during the first two weeks (d 0-14) and for the first 28 days (d 0-28). This is in agreement with our first study conducted during the summer of 1988. Differences in ADG during the 28-day medication period for the controls versus all three antibiotic-fed groups combined were .24 lbs during both trials representing a 21 and 19.3% advantage for the antibiotic-fed pigs during 1988 and 1989, respectively. Numerically speaking, the antibiotic-fed pigs grew faster than the controls during the entire 42-day study; however, some differences were observed in performance by antibiotic. The CSP250 and neoterramycin pigs gained significantly faster than the controls; however, the neomycin pigs were slower growing than the CSP250 pigs and not significantly different than the controls by day 42.

TABLE 2. AVERAGE DAILY GAIN AND FEED EFFICIENCY, LBS

		Treatment			
Variable	Period,d	Control	CSP250	Neomycin	Neoterramycin
ADG, lb	0-14	1.27^{a}	1.54^{b}	1.51^{b}	1.58^{b}
	14-28	1.22^{c}	1.51^{a}	1.31^{bc}	1.44^{ab}
	0-28	1.24^{a}	1.52^{b}	1.41^{b}	1.51^{b}
	28-42	1.19^{b}	1.61^{a}	1.23^{b}	1.40^{ab}
	0-42	1.22^{c}	1.55^{a}	1.37^{bc}	1.47^{ab}
F/G	0-14	1.88^{a}	1.80^{ab}	1.78^{b}	1.74^{b}
	14-28	2.79	2.63	2.78	2.60
	0-28	2.36^{a}	2.20^{b}	2.23^{ab}	2.14^{b}
	28-42	3.23	2.76	3.21	2.97
	0-42	2.63^{a}	2.39^{bc}	2.53^{ab}	2.38^{c}

^{a,b,c}Means within a row not having a superscript in common are different ($P<.05$).

Feed conversion also favored the antibiotic-fed pigs; however, differences were not as pronounced as differences in ADG. As can be seen from table 2, the CSP250 and neoterramycin treatment groups were more efficient than the controls during the medication period (d 0-28) and for the overall six-week study. However, the neomycin pigs were not significantly different from the controls. The advantage of the three antibiotic-fed groups compared to the controls was 7.6% for the 42-day trial. As shown in table 3, feed intake was less for the controls and the neomycin pigs compared to the CSP250 and neoterramycin treatments during the medication period (day 0-28) and for the entire six week study.

TABLE 3. FEED INTAKE PER PEN, LBS

	Treatment			
Period,d	Control	CSP250	Neomycin	Neoterramycin
0-14	201	233	226	232
14-28	276	333	304	313
0-28	477^{b}	567^{a}	530^{ab}	545^{a}
28-42	309^{b}	372^{a}	321^{b}	343^{ab}
0-42	786^{b}	939^{a}	851^{ab}	889^{a}

^{a,b}Means within a row not having a superscript in common are different (P<.05).

In general, health of the pigs was excellent; however, as shown in table 4, ADG by source was quite variable. Performance during the first two week period (ADGP1) was a good indicator of performance for the entire six week study (ADG42). The source C pigs were the fastest gaining and the B pigs the slowest gaining. Two pigs were removed from test; a slow growing B pig on day 28 and on day 14 an A pig due to a rectal prolapse.

TABLE 4. AVERAGE DAILY GAIN BY SOURCE, LBS

		Period				
Source	No. Hd.	0-14	14-28	0-28	28-42	0-42
A	26	1.40^{b}	1.34^{ab}	1.37^{c}	1.44	1.39^{b}
B	18	1.33^{b}	1.21^{c}	1.27^{c}	1.23	1.29^{b}
C	24	1.68^{a}	1.62^{a}	1.65^{a}	1.42	1.57^{a}
D	16	1.47^{b}	1.33^{bc}	1.40^{bc}	1.57	1.46^{ab}
E	18	1.67^{a}	1.49^{ab}	1.58^{ab}	1.27	1.48^{a}
F	42	1.38^{b}	1.28^{c}	1.33^{c}	1.28	1.32^{b}

^{a,b,c}Means within a column not having a superscript in common are different (P<.05).

High Fructose or Glucose Diets for Three Week Old Pigs

G.M. Hill, J.E. Link, C.A. Kerr, J.R. Turk

Introduction

Diets extremely high in fructose or glucose are very sweet and if palatable to the young weanling pig (3-4 wk) could reduce the amount of milk by-products necessary in these rations. However, the United States Department of Agriculture (USDA) Laboratory at Beltsville has reported that diets containing 50% fructose and no starch would result in copper deficiency if copper intakes were marginal. Additionally, humans consuming increasing amounts of fructose in corn syrup products, may be at risk if their copper intake is low. Most of the USDA data has been derived from studies using rats.

Objectives

Therefore, the objectives for this study were to:

(1) determine if three week old pigs would consume and grow on a diet high in fructose or glucose

(2) determine if pigs fed a high fructose or glucose diet low in copper (less than 1 ppm) would become copper deficient

(3) determine if pigs fed a starch diet low in copper would be protected from an induced copper deficiency

(4) determine if 6 ppm copper and/or starch was/were adequate to protect against this induced copper deficiency

Procedures

Forty pigs from the UMC herd were weaned at three weeks and placed on one of the following dietary treatments:

(1) 50% glucose, adequate copper (6 ppm)

(2) 50% glucose, low copper (< 1 ppm)

(3) 50% fructose, adequate copper

(4) 50% fructose, low copper

(5) 50% starch, adequate copper

(6) 50% starch, low copper

(7) 20% commercially available ration, high in milk products

The diets met the known nutrient requirements set by the National Research Council (NRC) for this age pig except when copper was low in the diet. Feed and deionized distilled water were available ad libitum.

Results

Pigs initially weighed approximately 17 pounds and gained equally well on all diets for the first four weeks of the study. Average weight and mortality are presented in Table 1. During week six of the study, two pigs died, and deaths continued in the glucose and fructose groups regardless of copper intake until the study ended after eight weeks.

Initial post mortem examination indicates cardiovascular involvement similar to what is observed with a vitamin E/selenium deficiency. While these nutrients were provided in the concentrations recommended by the NRC (7.2 IU vitamin E/lb.; 0.3 ppm selenium), they may be inadequate when sugar provides 50% of the calories. Laboratory and histological evaluation of the tissues have not been completed.

Conclusions

However, initial results allow us to conclude that:

(1) high intakes of glucose or fructose are extremely palatable to young pigs without providing dried skim milk in the ration;

(2) vitamin E and selenium recommendations of the NRC may be too low under some dietary conditions;

(3) 6 ppm copper does not protect the young pig when the diet is 50% glucose or fructose and hence may need to be increased;

(4) copper, selenium and vitamin E appear to interact when a high sugar diet is fed to three week old, weanling pigs, and

(5) pigs fed 50% starch were not affected by this interaction.

Table 1. Effect of carbohydrate and copper on body weight and mortality

Diet	Average Weight (lb.)					Mortality
	Initial	2 wk	4 wk	6 wk	8 wk	died/total
Starch						
- Cu	19	28	45	64	74	0/6
+Cu	18	28	43	63	75	0/6
Glucose						
- Cu	19	31	45	57	63	1/6
+Cu	21	31	46	62	68	3/6
Fructose						
- Cu	20	30	44	56	64	2/6
+Cu	20	31	42	55	55	3/6
Control	17	29	50	71	99	0/3

L-CARNITINE SUPPLEMENTATION OF DIETS FED TO BABY PIGS AND THE EFFECT ON PERFORMANCE

Lori S. Hoffman, Daniel J. Ivers, Trygve L. Veum and Mark R. Ellersieck.

Abstract

An experiment was conducted using 64 baby pigs to study the effect of adding L-carnitine to diets containing soy oil and isolated soy protein as evaluated by pig performance and nitrogen and energy utilization. Two levels of L-carnitine (0 vs 750 or 800 ppm) and two levels of soybean oil (low vs high) produced four treatments (2 x 2 factorial arrangement). Pigs were fed individually the first 21 days (phase 1). During Phases 2 (days 21 to 42) and 3 (days 42 to 63) pigs were paired within treatment groups, with two pigs per pen. There were no L-carnitine X soybean oil interactions for any criteria measured. When the treatments were compared based on metabolizable energy consumed per day, L-carnitine and soybean oil did **not** have any effect ($P>.05$) on pig performance, nitrogen utilization or energy utilization.

Introduction

Carnitine is involved in the transport of fatty acids containing eight or more carbons into the mitochondrial matrix of the cell where oxidation occurs (Broquist and Borum, 1982; Borum, 1983). Animal proteins are good sources of carnitine; while plant proteins contain little or no carnitine (Borum, 1983).

Because soy protein is a poor source of carnitine, and carnitine is required for the oxidation of long chain fatty acids; these experiments were conducted to evaluate the effects of adding L-carnitine to diets containing only soy protein with low or high additions of soy oil, an oil with a high concentration of long chain fatty acids.

Experimental Procedure

Pigs from 2 to 5 days of age averaging 2 kg were allotted to treatments by litter, gender and weight. Pigs were housed individually for metabolism studies during phase 1 (first 21 days) and fed their diets six times daily (every 3 hr starting at 8 a.m.). The lysine to calorie ratio was constant across treatments (Table 1).

A 5 day feces and urine collection was obtained from individual pigs during days 17 to 21 for nitrogen and gross energy analyses. Pigs were paired within treatments during Phases 2 (second 21 days) and 3 (third 21 days) and fed the dry

diets to appetite. Pig weights and diet consumption were collected weekly. Data were analyzed by Analysis of Covariance using metabolizable energy intake per day as the covariate (Snedecor and Cochran, 1967) utilizing SAS (1979).

Results and Discussion

There were no carnitine X soybean oil interactions for any of the criteria measured. Thus only main effects for carnitine and soy oil are presented in Tables 2 (period 1) and 3 (Periods 2 and 3).

The addition of L-carnitine or soy oil did not improve ($P>.05$) average daily gain or the gm of gain per Kcal of metabolizable energy consumed per day in periods 1, 2 or 3. Feed efficiency expressed as gm of gain per gm of diet consumed was greater ($P<.05$) for the high oil diets, which was expected due to the greater caloric density of those diets.

Ewan (1987) also found that L-carnitine did not improve performance of weanling pigs, nor was there any interaction between carnitine and level of dietary fat.

Added carnitine did not ($P>.05$) improve digestible or metabolizable energy utilization expressed as a percentage of gross energy consumed per day (Table 4). However, digestible and metabolizable energy values were slightly greater ($P<.05$) for the low compared to the high soy oil additions (Table 4). This suggests that the baby pig does not digest the long chain fatty acids in soy oil as well as older pigs.

Neither L-carnitine nor soy oil had any effect on nitrogen utilization as shown in Table 5. Nitrogen digestibility, biological value and net nitrogen utilization were similar for all treatments.

In conclusion, the addition of L-carnitine (750 or 800 ppm) to diets containing high levels of soy oil did not improve growth rate or the utilization of energy and nitrogen by the baby pig. Thus, it appears that the synthesis of L-carnitine in the body tissues is adequate to support the metabolic needs of the baby pig.

References

Broquist, H. P. and P. R. Borum (1982). Carnitine biosynthesis, nutritional implications. In: Advances in Nutritional Research, Vol. 4, pp. 181-204. H. H. Draper, ed. Plenum Press, New York.

Borum, P. R. (1983). Carnitine. In: Ann. Rev. Nutr. Vol. 3, p. 233-259. W. J. Darby ed. H. P. Broquist and R. E. Olson, Assoc. ed., Annual Reviews, Inc., Palo Alto, CA.

Ewan, R. C. 1987. Effect of L-carnitine on weanling pig performance. Iowa State University Swine Res. Rep. R481, p. 10.

Snedecor, G. W. and W. G. Cochran (1967). Statistical methods. 6th. The Iowa State University Press, Ames, Iowa.

SAS (1979). SAS User's Guide, SAS Institute, Inc., Raleigh, NC.

TABLE 1. COMPOSITION OF DIETS

Ingredients	Phase 1				Phase 2				Phase 3			
	Basal[a]		Basal[a] + Soybean Oil		Basal[a]		Basal[a] + Soybean Oil		Basal[a]		Basal[a] + Soybean Oil	
	%	gm/day	%	gm/day	%	gm/day	%	gm/day	%	gm/day	%	gm/day
Isolated soy protein[b]	27.13	68.89	30.29	68.89	19.57	74.63	22.22	74.63	---	---	---	---
Soybean meal, 48% CP	---	---	---	---	---	---	---	---	42.52	195.90	48.14	195.90
Soybean oil	1.18	3.00	12.31	28.00	1.15	4.38	13.22	44.38	2.17	10.00	14.74	60.00
Corn syrup solids[c]	31.30	79.48	23.61	53.70	34.94	133.22	26.93	90.43	23.34	107.54	13.67	55.63
Dextrose	31.30	79.48	23.61	53.70	34.94	133.22	26.93	90.43	23.34	107.54	13.67	55.63
Monocalcium phosphate	2.72	6.92	3.04	6.92	2.03	7.73	2.30	7.73	2.43	11.19	2.75	11.19
Calcium carbonate	1.58	4.00	1.75	4.00	1.09	4.15	1.24	4.15	1.40	6.44	1.58	6.44
Solka floc[d]	1.96	4.99	2.22	5.04	2.66	10.13	3.04	10.22	1.76	8.12	2.02	8.23
Vitamin premix[e]	1.05	2.66	1.17	2.66	1.21	4.60	1.37	4.60	1.15	5.28	1.30	5.28
Mineral premix[e]	1.50	3.81	1.68	3.81	1.73	6.60	1.97	6.60	1.43	6.58	1.62	6.58
L-cystine	.07	.19	.08	.19	.04	.14	.04	.14	.08	.39	.10	.39
DL-methionine	.05	.12	.05	.12	.06	.22	.07	.22	.08	.38	.09	.38
L-lysine.HCl	.16	.41	.18	.41	.60	2.29	.68	2.29	.22	1.00	.25	1.00
L-threonine	---	---	---	---	---	---	---	---	.07	.33	.08	.33
TOTAL	100.00	253.95	99.99	227.44	100.02	381.31	100.01	335.82	99.99	460.69	100.01	406.98
Analyzed Composition	%	gm/day	%	gm/day	%	gm/day	%	gm/day	%	gm/day	%	gm/day
Crude protein	23.89	56.22	26.65	55.65	16.33	62.27	18.95	63.64	20.33	93.66	22.51	91.61
Lysine	1.48	3.76	1.75	3.98	1.51	5.76	1.71	5.74	1.32	6.08	1.50	6.10
Methionine	.34	.86	.38	.86	.27	1.03	.31	1.04	.34	1.57	.38	1.55
Cystine	.32	.81	.35	.80	.22	.84	.24	.81	.35	1.61	.41	1.67
Tryptophan	.91	2.31	1.01	2.30	.66	2.52	.74	2.49	.28	1.29	.32	1.30
Threonine	.86	2.18	.96	2.18	.62	2.36	.70	2.35	.78	3.59	.88	3.58
	kcal/g	kcal/da	kcal/g	kcal/da	kcal/g	kcal/da	kcal/g	kcal/da	kcal/g	kcal/da	kcal/g	kcal/da
Gross energy	3.75	952	4.40	1000	3.68	1403	4.41	1481	3.41	1571	3.99	1624
Metabolizable energy	3.17	805	3.54	805	3.15	1200	3.57	1200	3.23	1490	3.66	1490

[a]Additional diets were formulated to contain 800 ppm L-carnitine in Phase 1, 750 ppm L-carnitine in Phase 2 and 750 ppm L-carnitine in Phase 3, producing a 2 x 2 factorial dietary arrangement. L-carnitine, Lonza, Inc., N. J.

[b]Isolated Soy Protein, Protein Technologies International, St. Louis, MO.

[c]Corn Syrup Solids, Staley Corp., Decatur, IL.

[d]Solka floc[R], James River Corp., Berlin, NH.

[e]Exceeded NRC (1988) requirements.

Table 2. PERFORMANCE MAIN EFFECT MEANS, DAYS 0 TO 21 BASED ON INDIVIDUAL PIG DATA

	L-carnitine, ppm		Soybean Oil, %		SE
	0	800	1.2	12.3	
Pig BW, g:					
Day 0	3931	3722	3604	4066	
21	10721	10347	9877	11222	
Average daily gain, g[a]:					
Days 0 to 21	165	165	167	163	4.176
Grams Gain/Kcal ME[a]:					
Days 0 to 21	.32	.32	.32	.31	.00043
Gain:Feed[a]:					
Days 14 to 21	1.06	1.06	1.02[b]	1.11[c]	.0142

[a]454 g = 1 pound. Adjusted values obtained using covariate analysis to equalize ME intake per day on a calculated basis.

Table 3. PERFORMANCE MAIN EFFECT MEANS, DAYS 21 TO 63 BASED ON PAIRED PIG DATA

	L-carnitine, ppm		Soybean Oil, %[a]		SE
	0	750	Low	High	
Pig BW, g:					
Day 42	19597	18203	16966[c]	20917[d]	
63	36710	32822	31556[e]	38060[f]	
Average daily gain, g[b]:					
Days 21 to 42	219	197	193	224	16.277
42 to 63	415	410	406	419	16.111
Grams Gain/Kcal ME[b]:					
Days 21 to 42	.18	.17	.16	.19	.0134
42 to 63	.18	.18	.18	.19	.0071
Gain:Feed[b]					
Days 21 to 42	.62	.56	.51[e]	.66[f]	.0438
42 to 63	.65	.64	.59[c]	.69[d]	.0238

[a]Soybean oil was added as follows:
Days 21 to 42 - Low is 1.2%, High is 13.2%
Days 42 to 63 - Low is 2.2%, High is 14.7%
[b]454 g = 1 pound. Adjusted values obtained using covariate analysis to equalize ME intake per day on a calculated basis.
[c,d]Means in the same row with different superscripts differ ($P<.01$).
[e,f]Means in the same row with different superscripts differ ($P<.05$).

Table 4. GROSS ENERGY, DIGESTIBLE ENERGY AND METABOLIZABLE ENERGY[a] MAIN EFFECT MEANS

	L-carnitine, ppm		Soybean Oil, %[b]		SE
	0	800	Low	High	
Grams/Day of Diet[c]	210(210)	210(210)	214(221)	205(198)	
Gross Energy, Kcal/Day	852	852	831[d]	873[e]	.299
Kcal Excreted/Day in Feces	48.8	50.1	45.1[d]	53.9[e]	1.819
Kcal Excreted/Day in Urine	38.3[d]	35.1[e]	37.1	36.4	.8984
Digestible Energy, KcalDay	803	802	786[d]	819[e]	1.873
Digestible Energy, %	94.32	94.12	94.61[f]	93.84[g]	.002
Metabolizable Energy, Kcal/Day	765	767	749[d]	783[e]	2.243
Metabolizable Energy, %	89.80	89.99	90.13	89.66	.003

[a]454 g = 1 pound. Samples obtained during the collection period, Days 17 to 21 of Phase 1, 100% DM Basis, all values are adjusted values obtained using covariate analysis to equalize ME intake per day on a calculated basis.
[b]Soybean oil was added as follows: Low is 1.2% and High is 12.3%.
[c]Adjusted diet intake values during the balance are reported in parenthesis.
[d,e]Means in the same row with different superscripts differ ($P<.01$).

Table 5. MAIN EFFECT MEANS FOR NITROGEN BALANCE[a]

	L-carnitine, ppm		Soybean Oil, %[b]		SE
	0	800	Low	High	
Diet, Grams Nitrogen/Day/Pig[c]	8.46(8.46)	8.46(8.46)	8.19(8.46)	8.74(8.45)	.0001
Grams Fecal Nitrogen/Day/Pig	.45	.47	.46	.47	.0202
Grams Urinary Nitrogen/Day/Pig	2.20[d]	2.04[e]	2.06	2.18	.0526
Nitrogen Balance, Grams/Day	5.81	5.94	5.95	5.80	.0603
Nitrogen Digestibility, %	94.72	94.39	94.64	94.47	.2326
Biological Value, %	72.44	74.28	74.21	72.51	.6805
Net Nitrogen Utilization, %	68.63	70.12	70.25	68.51	.7145

[a]454 g = 1 pound. Samples obtained during the collection period, Days 17 to 21 of Phase 1, 100% DM basis, all values are adjusted values obtained using covariate analysis to equalize ME intake per day on a calculated basis.
[b]Soybean oil was added as follows: Low is 1.2% and High is 12.3%.
[c]Adjusted diet intake values during the balance are reported in parenthesis.
[d,e]Means in the same row with different superscripts differ ($P<.05$).

THE EFFECT OF SPACE ALLOCATION ON PERFORMANCE OF FINISHING HOGS FED TO 250 LBS[1]

D. VANSKIKE, C. ZUMBRUNNEN AND G. W. JESSE

SUMMARY

During the summer of 1989 seventy crossbred barrows and gilts were used to compare the effect of providing 6, 8, 10 or 12 sq. ft. of space per head in confinement on performance. Although average daily gain and feed efficiency were not significantly affected by treatment (P>.05) there was a tendency for those provided 10 sq. ft. to out perform the 6 sq. ft. treatment. Average daily gain and feed per unit of gain were 1.57, 1.66, 1.79 and 1.68 lbs and 3.86, 3.92, 3.69 and 3.76 lbs for the 6, 8, 10 and 12 sq. ft. treatments, respectively. The number of days required for 50% of the hogs in each pen to reach a 250 lb slaughter weight averaged 84, 77, 70 and 73 for the 6, 8, 10 and 12 sq. ft. treatments, respectively.

INTRODUCTION

Present guidelines regarding recommended floor space for finishing hogs in confinement are based upon an end weight of 220-230 lbs rather than the heavier weights of 250-260 lbs which are more prevalent today. Realizing that 8 sq. ft. per pig may not be enough room when feeding to an average slaughter weight of 250 lbs, the North Central Region Committee on Confinement Management of Swine (NCR-89) recently initiated a cooperative research project to evaluate various space allocations during finishing. The specific treatments compared included: 6, 8, 10 and 12 sq. ft. per pig from an initial weight of 120 lbs to a final weight of 250 lbs. This report is of a trial conducted during the summer of 1990 at the University of Missouri.

PROCEDURES

Seventy crossbred barrows and gilts of Yorkshire, Landrace and Duroc descent, averaging 120 lbs were used for this study which included two replications of all four treatments. Details of the experimental design are shown in table 1.

Pigs were assigned at random, within weight group and sex to treatment. The original intent was to weigh all pigs on test on April 4; however, the pigs of replicate 2 were lighter than the desired 115 to 120 lb average starting weight; hence, they were started on test a week later (April 11) than the replicate 1 pigs.

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[1]A cooperative study with the North Central Region Committee on Confinement Management of Swine.

TABLE 1. EXPERIMENTAL DESIGN[a]

Treatment	No. pigs/pen	No. barrows/pen	No. gilts/pen
6 sq ft	10	7	3
8 sq ft	10	7	3
10 sq ft	8	5	3
12 sq ft	7	5	2

[a]Refers to pigs per replicate. The trial included two replicates; hence a total of 70 pigs were used.

The test facility was a modified-open-front barn with a gutter flush waste handling system. Each pen contained a two-hole Smidley feeder and two nipple waterers. A thermostatically-controlled curtain was on the south side and doors on the north opened for summer ventilation. Each original pen was 16 ft. long and varied in width from 5 ft. 5.5 in. for the pen area (11 ft. in length) to 5 ft. 10 in. wide for the 5 ft. gutter area. Total available space (excludes feeder space) for each pen (86.2 sq. ft.) determined the number of pigs each treatment would accommodate. All four pens used for each replicate were modified to obtain the correct area for each treatment. This modification was accomplished by blocking off 5 ft., 2 ft., 2 ft. and .5 in. of the back area of each pen for the 6, 8, 10 and 12 sq. ft. treatments, respectively.

Pig weights and pen feed consumption were determined at 14 day intervals until the pen averaged 200 lbs. After this, all pigs within a replicate were weighed weekly and individual pigs were removed from test when they reached 250 lbs. After at least half of the pigs in a pen had reached 250 lbs, the remainder of the pen was fed for no more than three weeks or until the remaining group averaged 250 lbs.

The data were analyzed by analysis of variance with pen mean used as the experimental unit. Means were separated by Fisher's Least Significant Difference using a protected F.

RESULTS AND DISCUSSION

Growth rate (ADG), feed intake and feed efficiency by treatment are shown in table 2. Although differences were not significant ($P>.05$), there was a tendency for those pigs provided 6 sq. ft. to be slower growing than those provided 10 sq. ft. ($P>.12$). These data seem to indicate that there is no advantage in providing more than 10 sq. ft. per head; however, one should keep in mind the fact that available pen space was not adjusted as individuals reached slaughter weight and were removed from test.

As indicated in table 3, time required for at least 50% of the hogs to reach the desired 250 lbs was 84, 77, 70 and 73 days for the 6, 8, 10 and 12 sq. ft. treatments, respectively. Hence, available space per head, once half of the pigs were removed from each pen, was 9.2, 12.3, 11.4 and 14.0 sq. ft. or greater for the respective treatments. This may partially explain why performance for the 8, 10 and 12 sq. ft. treatments was similar.

TABLE 2. AVERAGE DAILY GAIN, FEED INTAKE AND FEED EFFICIENCY, LBS

Variable	Treatment			
	6 sq ft	8 sq ft	10 sq ft	12 sq ft
Initial wt	120.3	117.6	118.1	125.2
Final wt	251.4	250.6	256.2	253.5
Days fed[a]	84.0	81.5	77.8	77.5
ADG[b]	1.57	1.66	1.79	1.68
FI /hd/d	5.75	5.97	6.22	6.02
Feed/Gain[b]	3.86	3.92	3.69	3.76

[a]All pigs of one pen of the 6 sq. ft. and 10 sq. ft. treatments and both pens of the 12 sq. ft. treatment were weighed off test on or before day 91. The remaining pen of the 6 and 10 sq. ft. treatments and both pens of the 8 sq. ft. had pigs that were fed to day 98.

[b]Means were not different (P>.05).

TABLE 3. PERCENT OF HOGS REACHING SLAUGHTER WEIGHT

Days on test	Treatment			
	6 sq ft	8 sq ft	10 sq ft	12 sq ft
56	0.0	0.0	6.2	0.0
63	0.0	15.0	12.5	14.2
70	20.0	35.0	50.0	42.8
77	35.0	50.0	56.2	64.2
84	50.0	55.0	68.7	71.4
91	85.0	65.0	93.7	100.0

GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF PIGS IMPLANTED WITH SUSTAINED RELEASE PORCINE SOMATOTROPIN

R.O. Bates, G.L. Allee, H.B. Hedrick, J.C. Rea, and C.D. Knight[1]

Summary

Barrows and gilts that weighed approximately 150 lbs were treated weekly with one of four different porcine somatotropin (PST) dosages in a sustained release system. Pigs consumed a 14% crude protein diet until 240 lbs. Pigs treated with PST grew faster, were leaner and more feed efficient than controls. Muscle quality scores of pigs treated with PST were not different when compared to controls.

Introduction

Porcine somatotropin (PST) is a naturally occurring hormone that is composed of amino acids and is produced in the pituitary of the pig's brain. In the past, experiments evaluating supplementation with PST were limited due to the difficulty of harvesting PST from slaughtered pigs. However, with the development of biotechnology methods PST can be synthesized from bacteria and mass produced. Many studies have evaluated the daily injection of PST on pig growth and carcass traits. These studies reported that PST improved growth rate, feed efficiency (feed/gain) and many carcass traits. However, daily injection of pigs is impractical in commercial production. This study was conducted to evaluate the response of pigs implanted weekly with PST.

Methods

During the summer and fall of 1988 four implant dosages of PST were compared to a control. Barrows and gilts used in this study were from the UMC Research Swine Farm and two different commercial farms. Four replicates were evaluated. Each replicate consisted of five pens of barrows and five pens of gilts. Each pen had seven pigs with 9.4 sq. ft. per pig. Pigs were housed in an enclosed barn with completely slatted pens over a shallow flush gutter.

Pigs were placed in the barn 2-3 weeks before the study began. Each replicate began the experiment when pigs averaged approximately 150 lbs. At initiation pigs were randomized, by pen

[1]Monsanto Co., St. Louis, MO

and sex to receive one of four PST implant dosages or not be implanted, as a control. Implants were placed into the neck, behind the ear at an angle toward the head. Implantation sights were cleaned with alcohol before each treatment. Pigs were weighed and implanted each week until they reached 240 lbs. Dosages evaluated were 12, 24, 36 and 48 mg. During the study pigs consumed a 13.75% crude protein corn, soybean meal diet that contained .66% lysine. At 240 lbs, four pigs in each pen were slaughtered and carcass data collected.

Results and Discussion

Growth performance is reported in table 1. Pigs treated with the 24 mg implant grew faster than the controls, while pigs treated with the 36 and 48 mg implants were slower growing than controls. This may be due to the 36 and 48 mg treated pigs consuming less feed when compared to controls. Feed efficiency was improved among all treatment groups when compared to controls, with the 24 mg treated pigs having the lowest feed efficiency.

Carcass traits are presented in table 2. Dressing percent was reduced among pigs treated with the 36 mg dosage, as compared to controls while carcass length increased for pigs treated with the 48 mg dosage. Backfat measured at the first, tenth, and last rib and the last lumbar vertebrae was decreased by PST treatment; however, reduction was not consistent at the different locations. Average backfat (average of first rib, last rib and last lumbar vertebrae) was significantly decreased by each PST treatment when compared to controls. Loin muscle area did not change when pigs were treated with PST. Also muscle quality indicators (color score, firmness score and marbling score) were not significantly changed when pigs were treated with PST.

Results presented here are not consistent with many other published reports concerning PST. In this study, PST treated pigs did not consistently grow faster and improvement in feed efficiency was not as dramatic as other studies. McLaren et al., (1990) reported that average daily gain and feed efficiency were improved by as much as 21% and 37%, respectively, when pigs were injected daily with PST. Backfat thickness did decrease but no difference among treatments was observed for loin muscle area. In contrast, Grebner et al., (1987) reported that tenth rib fat decreased by as much as 58% while loin muscle area increased by 13% when pigs were injected daily with PST. On the other hand, PST did not change muscle quality indicators which is consistent with other studies.

In this study, it must be pointed out that PST was administered weekly in a sustained release system while many other studies injected pigs daily with PST. This may account for some of the inconsistencies observed. Also the ration fed was a typical 14% crude protein finishing ration not a ration with

increased protein and energy. Many of the published studies evaluating PST used rations with higher energy and protein composition than was used here.

Conclusion

Treatment of pigs with PST in a sustained release system did improve average daily gain and feed efficiency. Backfat thickness was decreased while muscle quality indicators and loin muscle area were not significantly changed. PST did cause a desired response in growth, feed efficiency and leanness in pigs consuming a typical 14% crude protein finishing ration.

Literature Cited

Grebner, G.L., F.K. McKeith, J. Novakofski, R.A. Easter, D.G. McLaren, K. Benner and P.J. Bechtel. 1987. Carcass characteristics of pigs injected with different levels of natural porcine somatotropin from 57 to 103 kg. J. Anim. Sci. 65 (Suppl. 1):245 (Abstr.).

McLaren, D.G., P.J. Bechtel, G.L. Grebner, J. Novakofski, F.K. McKeith, R.W. Jones, R.H. Dalrymple and R.A. Easter. 1990. Dose response in growth of pigs injected with porcine somatotropin form 57 to 103 kilograms. J. Anim. Sci. 68:640.

TABLE 1. LEAST SQUARES MEANS OF GROWTH PERFORMANCE OF PIGS IMPLANTED WITH SUSTAINED RELEASE PST

	Treatment				
Trait	Control	12mg	24mg	36mg	48mg
Average Daily Gain[bcd] (lbs/day)	1.71	1.69	1.79	1.62	1.63
Average Daily Feed[cd] Consumed (lbs/day)	6.53	6.37	6.48	5.76	5.91
Feed Efficiency[abcd] (lbs feed/lb gain)	3.86	3.66	3.47	3.67	3.56

[a]Controls differed from 12 mg (P<.05).
[b]Controls differed from 24 mg (P<.05).
[c]Controls differed from 36 mg (P<.05).
[d]Controls differed from 48 mg (P<.05).

TABLE 2. LEAST SQUARES MEANS OF CARCASS TRAITS OF PIGS IMPLANTED WITH SUSTAINED RELEASE PST

Trait	Treatment				
	Control	12mg	24mg	36mg	48mg
Dressing Percent[c] (%)	72.9	73.0	72.6	71.4	72.1
Carcass Length[d] (in.)	31.6	31.6	31.7	31.8	32.2
First Rib Backfat[d] (in.)	1.76	1.62	1.65	1.67	1.58
Last Rib Backfat[bcd] (in.)	1.06	1.00	.98	.95	.85
Last Lumbar Backfat[d] (in.)	1.11	1.07	1.06	1.00	.97
Average Backfat[abcd] (in.)	1.31	1.23	1.23	1.21	1.13
Loin Muscle Area (in^2.)	4.95	4.90	4.89	4.78	4.74
Color Score (1-5 scale)	2.0	2.0	2.0	2.0	2.1
Firmness Score (1-3 scale)	2.0	2.1	1.9	2.1	1.9
Marbling Score (1-5 scale)	1.5	1.6	1.6	1.5	1.5

[a]Controls differed from 12 mg ($P<.05$).
[b]Controls differed from 24 mg ($P<.05$).
[c]Controls differed from 36 mg ($P<.05$).
[d]Controls differed from 48 mg ($P<.05$).

EFFECT OF A FEED ADDITIVE ENZYME (RELEFE) ON THE PERFORMANCE OF FINISHING HOGS[1]

G.W. Jesse

SUMMARY

During a 10-week finishing study, 80 university-raised, crossbred barrows and gilts weighing 116 lbs initially, were used to compare the effect of including an enzyme (RELEFE) in a corn-soybean meal diet on performance. Growth rate and feed efficiency of the control pigs versus the enzyme-fed pigs for the 70-day trial were not different (1.61 vs 1.63 lbs and 3.65 vs 3.62, respectively). However, a significant increase in ADG for the first 56 days was noted for the enzyme-fed pigs, which suggests that additional studies are warranted.

INTRODUCTION

Realizing that feed cost represents the greatest single cost of producing pork, producers are interested in identifying feed additives that will result in optimum performance of the growing-finishing pig. Generally speaking producers search for an antibiotic feeding program that will be most effective on their farm. However, enzymes are another type of feed additive that merit consideration as enhancers of swine performance. RELEFE Corporation of Russellville, Arkansas advocates that a maximum stabilized enzyme (MSE) that they manufacture (RELEFE), when fed during the growing-finishing phase, will result in increased growth rate and feed efficiency. In addition, reduced odor and less manure are also cited as advantages of feeding RELEFE.

The objective of this 70-day trial was to determine the effect of adding 2 lbs of MSE (RELEFE) to a corn-soybean meal diet on the growth rate and feed efficiency of finishing hogs.

PROCEDURES

On December 21, 1989 a 10-week finishing study was initiated to determine the effect of including a maximum stabilized enzyme (RELEFE) in a corn-soybean meal diet on performance. Eighty university-raised, crossbred barrows and gilts (40 of each sex) of Duroc, Landrace and Yorkshire descent were used for this study. Average beginning weight and age were 116 lbs and 15 weeks.

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[1]Partial funding for this study was provided by RELEFE Corporation of Russellville, Arkansas.

The pigs were randomly assigned, within sex, to treatment and replicate. As shown in table 1, treatments were replicated four times using 10 pigs per pen. Each pen included 5 barrows and 5 gilts.

TABLE 1. EXPERIMENTAL DESIGN

Treatment[a]	No. Pigs[b]	No. Pens	Average Beginning Wt., lbs
Control	40	4	117.6
MSE	40	4	114.5

[a]MSE refers to maximum stabilized enzyme (RELEFE) included at the rate of 2 lbs per ton of diet.

[b]Represents 20 barrows and 20 gilts per treatment or 5 barrows and 5 gilts per pen.

The test facility was a modified-open-front barn with an open gutter flush and a thermostatically-controlled curtain on the south side. Each pen was 5.5' wide and 16' long and included a two-hole Smidley feeder and one nipple waterer. Total area per pig was 8.5 sq. ft.

The basal diet was a 14% crude protein, corn-soybean meal diet (meal form) which was formulated to meet or exceed NRC recommendations. Lysine, calcium and total phosphorus were formulated to be .73, .65, and .55%, respectively. The enzyme-added diet (MSE) contained 2 lbs per ton of RELEFE. The guaranteed crude protein, crude fat and crude fiber specifications and a list of ingredients for this product are shown in table 2. Neither diet (Control or MSE) contained an antibiotic or anthelmintic. However, all pigs had been previously dewormed and vaccinated for erysipelas prior to this study.

Pig weights and pen feed consumption were determined every 14 days throughout the study. Growth rate (ADG) and feed efficiency (F/G) were statistically compared on a pen basis by analysis of variance with means separated by Fisher's Least Significant Difference.

RESULTS AND DISCUSSION

As shown in table 3, average daily gain (ADG) and feed efficiency (F/G) of the Control and MSE treatments were not different ($P>.05$) for the 70-day finishing study. ADG and F/G for the Control and MSE treatments were 1.61 vs 1.63 lbs and 3.65 vs 3.62 lbs, respectively. It is interesting to note that accumulative ADG for the first 56 days (ADG 0-56) favored the

enzyme-fed pigs (MSE; 1.60 vs 1.52 lbs, respectively). However, ADG favored the Control pigs during the subsequent two-week period (ADG 56-70) and as a result, performance for the entire 70-day study did not differ by treatment. Feed efficiency was not different for any of the periods compared.

TABLE 2. COMPOSITION OF MSE (RELEFE)[a]

Crude protein, not less than 15%
Crude fat, not less than 4%
Crude fiber, not more than 15%

Ingredients:

Dried A Oryzae fermentation products
Dried cane molasses
DL-Methionine
Calcium carbonate
L-lysine
Corn distillers dried grain
Wheat distillers dried grain
Vitamin E supplement
Vitamin D-activated plant sterol
Vitamin B-12 supplement
D-glucose
Malt
Yeast

[a]Manufacturer - RELEFE Corporation, 235 South Cumberland, Russellville, Arkansas 72801.

Results of a field study conducted on the Wayne Jorgensen Farm at Russellville, Arkansas during a similar period of time a year earlier than this study (10/10/88 to 3/9/89) noted that MSE-fed pigs were 5% faster gaining and 9.46% more efficient than control pigs. Their study utilized 120 pigs from 45 to 225 lbs. The performance of our pigs through day 56 showed a 5.26% advantage in ADG for the MSE-fed pigs and a non-significant 2.96% advantage in feed conversion.

Overall, the health of the pigs was good; however, two pigs died and one other pig was removed due to poor performance. One Control pig died on day-42 due to Pasteurella pneumonia and an MSE pig died on day-14 from ileitis. The poor performing pig was an MSE pig suspected of having ileitis.

In conclusion, the inclusion of MSE (RELEFE) did not increase performance. However, the significant increase in ADG for the first 56 days suggests that additional research is warranted.

TABLE 3. AVERAGE DAILY GAIN AND FEED EFFICIENCY, LBS

Item	Period, d	Treatment	
		Control	MSE
Beginning Weight	December 21	117.6	114.5
Ending Weight	March 1	231.0	229.2
ADG	0-14	1.46	1.46
	14-28	1.74	1.80
	0-28	1.60	1.64
	28-42	1.35	1.48
	0-42	1.52	1.61
	42-56	1.46	1.58
	0-56	1.52[a]	1.60[b]
	56-70	1.96	1.76
	0-70	1.61	1.63
F/G	0-14	3.29	3.36
	14-28	3.19	3.08
	0-28	3.23	3.21
	28-42	4.35	4.07
	0-42	3.55	3.48
	42-56	4.19	3.98
	0-56	3.71	3.60
	56-70	3.47	3.74
	0-70	3.65	3.62

[a,b]Means within a row with a different superscript are different ($P<.05$).

THE EFFECTS OF RACTOPAMINE IN FINISHING PIG DIETS VARYING IN CRUDE PROTEIN QUANTITY AND QUALITY LEVEL

G. W. Jesse[1], C. A. Martin[2], J. A. Miyat[3] and H. B. Hedrick[4]

SUMMARY

One hundred and fourteen hogs were used during a 47-day finishing trial to compare the effects of four different levels of Ractopamine (0, 5, 10 and 20 ppm) and three diets (17% corn-soy, 14% complex and 16% complex) on performance and carcass characteristics. Growth rate and feed efficiency varied from 2.01 to 1.77 lbs and 3.30 to 3.83 lbs per pound of gain, respectively; however, these differences were not significant (P>.05). Loineye area and muscling score increased with an increased level of Ractopamine; however, backfat thickness was not significantly affected. The complex protein supplement diets produced higher marbling scores than the corn-soy diet.

INTRODUCTION

During the summer of 1989 a finishing trial was conducted at the University of Missouri Southwest Center, located at Mt. Vernon, to demonstrate the effects of feeding a repartitioning agent (Ractopamine) on swine performance and carcass traits. A second objective was to determine the efficacy of different levels of Ractopamine in finishing diets varying in crude protein level and quality.

PROCEDURES

One hundred and fourteen crossbred barrows and gilts averaging 146.7 lbs were used for this study which was initiated, on August 30, 1989. The treatments compared during this study included four different levels of Ractopamine (0, 5, 10 and 20 ppm) and three diets (17% corn-soy, 14% complex and 16% complex) totalling nine different combinations as shown in table 1. All nine treatments were replicated three times.

The pigs for this study were selected from a group of 144 crossbred barrows and gilts that were utilized in a six-week feeder pig management study, which terminated on August 9. Pigs

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[1]Animal Sciences Dept., University of Missouri

[2]MFA Incorporated

[3]Lilly Research Laboratories

[4]Food Science & Nutrition Dept., University of Missouri

were randomly assigned to treatment, within weight group and sex, and allotted to their new pen on August 10. Due to a shortage of suitable pigs, as well as an unequal number of barrows and gilts, the number and sex distribution differed by replicate as noted by the footnote of table 1.

TABLE 1. EXPERIMENTAL DESIGN

Treatment No.	Diet	Ractopamine, ppm	No. Pens[a]	No. Pigs
1	17% Corn-soy[b]	0	3	12
2	17% Corn-soy	5	3	12
3	17% Corn-soy	10	3	14
4	14% Complex	0	3	13
5	14% Complex	5	3	12
6	14% Complex	10	3	13
7	16% Complex	0	3	14
8	16% Complex	10	3	12
9	16% Complex	20	3	12

[a]Replicate I included 5 pigs per pen (3 barrows and 2 gilts). Replicate II had 4 pigs per pen (2 barrows and 2 gilts). Replicate III included 5 pens with 3 pigs each (2 barrows and 1 gilt); 2 pens with 4 pigs each (3 barrows and 1 gilt) and 2 pens with 5 pigs each (3 barrows and two gilts).

[b]The original intent was for this diet to be a 16% corn-soy; however, 48% SBM was inadvertently used to formulate diets 1, 2 and 3 rather than 44% SBM resulting in a 17.3% crude protein level.

During a three week transition period (August 9 to 30), all pigs were fed a 14% crude protein, corn-soybean meal diet without antibiotics for 14 days followed by 7 days of a 16% crude protein, corn-soybean meal diet that included 40 g of Tylan per ton. The intent of this treatment was to remove any carry over effects of the feeder pig management study and secondly to cure any morbidity problems that might have been present. All pigs were weighed on test on August 30 and provided their respective test diet for the duration of the trial.

All diets were formulated by MFA Incorporated and prepared at their mill at Mexico, MO. The complex protein diets were formulated to investigate the use of alternative protein sources in addition to soybean meal. Ractopamine was supplied by Lilly Research Labs as a 2% premix with 1/2 lb of Ractopamine premix providing 5 ppm.

The test facility was an open-front barn with 30 pens that were 5' x 15'. The floor and pen dividers were solid concrete and the back wall opened to allow for natural ventilation. Each pen was equipped with one nipple waterer and a one-hole Smidley self feeder. A thermostatically-controlled overhead sprinkler system was available for cooling the pigs when the temperature exceeded 80 degrees F.

Pig weights and pen feed consumption were obtained on day 28 and day 47 (October 16). The intent was to terminate the study when all three replicates, collectively, averaged 235 lbs. One barrow and one gilt from each pen (54 hd) closest to the median weight for the pen were transported to the University of Missouri at Columbia and evaluated via the Whole Body (^{40}K) Counter prior to their transport to the Wilson Foods slaughter facility at Marshall, MO. All other pigs were transported directly to Wilson Foods for slaughter. Standard carcass measures including weight, length, backfat thickness and loineye area were obtained on the 54 head that were evaluated at Columbia. Carcasses were also evaluated for color, firmness, marbling and muscling by Dr. H. B. Hedrick of the University of Missouri Food Science and Nutrition Department.

RESULTS AND DISCUSSION

Average daily gain and feed efficiency figures for all nine treatments are shown in table 2. Growth rate (ADG) ranged from 2.01 to 1.77 lbs and feed efficiency from 3.30 to 3.83 lbs/ lb of gain; however, these differences were not significant (P>.05). Unfortunately the main effects of diet and Ractopamine could not be compared as a 3 x 3 factorial due to the inclusion of 20 ppm of Ractopamine for treatment 9. However, the effects of 0 and 10 ppm of Ractopamine across all three diets and the effects of 0, 5 and 10 ppm for the 17% corn-soy and the 14% complex diets are shown in table 3.

TABLE 2. AVERAGE DAILY GAIN AND FEED EFFICIENCY, LBS

Treatment		Variable[a]	
Diet	Ractopamine	ADG	F/G
17% CS	0	1.90	3.65
17% CS	5	2.01	3.39
17% CS	10	1.93	3.30
14% CX	0	1.82	3.81
14% CX	5	1.88	3.58
14% CX	10	1.86	3.67
16% CX	0	1.80	3.65
16% CX	10	1.89	3.83
16% CX	20	1.77	3.47

[a]Means were not different (P>.05).

The effect of diet and level of Ractopamine on selected carcass traits is shown by table 4. Significant differences (P<.05) were present for loin eye area (LEA), muscling score and marbling score. Average backfat thickness and pounds of lean body mass (LBM) were not affected by treatment. LEA and muscling score increased with an increased level of Ractopamine; however, the changes in marbling varied by diet.

Table 5 shows a main effects analysis (3 x 2 and 2 x 3) for several quantitative and qualitative carcass traits. The complex protein supplement diets (14% CX and 16% CX) produced higher marbling scores than the 17% corn-soy diet. Ractopamine resulted in heavier muscled pigs as indicated by LEA, muscling score, grams of potassium (K) and pounds of lean body mass (LBM). However, it is interesting to note that backfat thickness was not consistent with level of Ractopamine.

TABLE 3. AVERAGE DAILY GAIN AND FEED EFFICIENCY BY DIET OR LEVEL OF RACTOPAMINE, LBS

	Type of Analysis[ab]			
	3 X 2		2 X 3	
Variable	ADG	F/G	ADG	F/G
Diet				
17% CS	1.91	3.47	1.95	3.45
14% CX	1.79	3.74	1.85	3.69
16% CX	1.80	3.74	----	----
Ractopamine				
0	1.84	3.70	1.86	3.73
5	----	----	1.94	3.49
10	1.90	3.60	1.90	3.48

[a]Due to the inclusion of 20 ppm of Ractopamine for treatment 9 (16% CX - 20 ppm), a 3 x 3 factorial analysis could not be run; therefore we have chosen to compare the three diets with two levels of Ractopamine (0 and 10 ppm) and two diets (17% CS and 14% CX) with three levels of Ractopamine, shown via this table as 3 X 2 and 2 X 3, respectively.

[b]Means were not different (P>.05).

TABLE 4. EFFECT OF DIET AND RACTOPAMINE ON CARCASS TRAITS

Treatment		Variable				
Diet	Ractopamine	Avg BF	LEA	Musc score	Marb score	LBM
17% CS	0	1.21	4.60^{bc}	4.83^{de}	2.50^{bcd}	130.3
17% CS	5	1.36	5.17^{a}	5.83^{abc}	2.16^{d}	142.8
17% CS	10	1.24	5.25^{a}	6.50^{a}	2.33^{cd}	140.4
14% CX	0	1.47	4.21^{c}	4.33^{e}	3.16^{abc}	131.4
14% CX	5	1.19	5.01^{ab}	5.50^{bcd}	3.33^{ab}	133.8
14% CX	10	1.37	4.93^{ab}	6.16^{ab}	3.50^{a}	134.5
16% CX	0	1.24	4.42^{c}	5.00^{cde}	3.33^{ab}	134.5
16% CX	10	1.36	5.05^{ab}	5.50^{bcd}	3.00^{abcd}	141.7
16% CX	20	1.16	5.02^{ab}	6.33^{ab}	3.00^{abcd}	137.5

^{abcde}Means not having at least one superscript in common are different (P<.05).

TABLE 5. QUANTITATIVE AND QUALITATIVE CARCASS CHARACTERISTICS

Analysis Variable	Diet			Ractopamine		
	17% CS	14% CX	16% CX	0	5	10
3 X 2 Analysis						
Quantitative traits						
Carc wt, lb	174.4	180.9	180.4	176.2	----	180.8
Length, in	30.6	31.3	31.3	31.2	----	31.0
LEA, sq in	4.92	4.57	4.74	4.41[c]	----	5.08[d]
Avg BF, in	1.23	1.42	1.30	1.31	----	1.32
BF 10th, in	1.06	1.25	1.08	1.16	----	1.10
Qualitative traits[a]						
Musc score	5.66	5.25	5.25	4.72[c]	----	6.05[d]
Marb score	2.41[c]	3.33[d]	3.16[e]	3.00	----	2.94
Color score	3.00	3.00	3.00	3.00	----	3.00
Firm score	2.16	2.08	2.33	2.22	----	2.16
^{40}K traits[b]						
K, g	142.3	134.5	144.1	134.9[c]	----	145.7[d]
Fat, %	36.5	37.4	37.4	36.8	----	37.3
Protein, %	14.5	14.1	14.3	14.2	----	14.2
LBM, lbs	135.4	132.9	138.2	132.0[c]	----	138.9[d]
2 X 3 Analysis						
Quantitative traits						
Carc wt, lb	176.6	177.5	----	176.9	175.8	178.4
Length, in	30.7[c]	31.1[d]	----	31.3[c]	30.7[d]	30.6[d]
LEA, sq in	5.00	4.72	----	4.40[c]	5.09[d]	5.09[d]
Avg BF, in	1.27	1.34	----	1.34	1.27	1.31
BF 10th, in	1.04	1.17	----	1.23	1.00	1.09
Qualitative traits[a]						
Musc score	5.72	5.33	----	4.58[c]	5.66[d]	6.33[d]
Marb score	2.33[c]	3.33[d]	----	2.83	2.75	2.91
Color score	2.94	3.00	----	3.00	2.91	3.00
Firm score	2.11	2.22	----	2.08	2.25	2.16
^{40}K traits[b]						
K, g	146.1	136.6	----	131.6[c]	147.3[d]	145.1[d]
Fat, %	36.7	37.0	----	37.0	36.7	36.8
Protein, %	14.5	14.2	----	14.1	14.5	14.5
LBM, lbs	137.8	133.1	----	130.7	138.4	137.3

[a]Subjective scores used were 1-9, 1-5, 1-5 and 1-3 for muscling, marbling, color and firmness scores, respectively.

[b]These traits were determined via whole body (^{40}K) counting. LBM refers to lean body mass.

[c,d,e]Means within a row by diet or level of Ractopamine not having a superscript in common are different ($P<.05$).

THE EFFECTS OF COLD ON PERFORMANCE, CARCASS RESPONSES AND THERMAL BALANCE OF FINISHING HOGS TREATED WITH A SINGLE PORCINE SOMATOTROPIN PROLONGED RELEASE IMPLANT (PST-I)

B. A. Becker[1], C. D. Knight[2], G. W. Jesse[3], J. Lopez[3], H. D. Hedrick[3] and C. A. Baile[2]

SUMMARY

A study was conducted to evaluate the performance, carcass characteristics, and thermal balance of finishing hogs treated with porcine somatotropin (PST) and maintained in cold environmental conditions for 28 or 35 days. Performance was determined weekly. At the end of the trial hogs were slaughtered. One-half of the carcass was evaluated for various parameters; the other half was processed for proximate analysis of carcass composition. Heat production was estimated from the above analysis. Rectal temperatures and respiratory rates were measured as indicators of thermal balance. In the cold environment, the benefits of treatment with PST were achieved in performance. No differences in various carcass parameters were found due to PST or cold conditions. Energy utilization appeared to be different in animals treated with PST, but this difference was not detrimental to thermal balance.

INTRODUCTION

Last year we reported that the beneficial effects of supplementing finishing swine with porcine somatotropin (PST) could be achieved under hot environmental conditions. Those results demonstrated that the PST implant we used had no significant effect on average daily gain but did reduce feed consumption and improve feed efficiency, both under thermoneutral (64 to 68° F) and hot (80 to 95° F) conditions. However, it had been proposed (Curtis, 1989) that the reduced amount of body fat associated with PST treatment would make the hogs more vulnerable to cold conditions. Further, the benefit of reduced feed intake, and hence feed efficiency, would be lost in hogs in the cold environment as the hogs increased their feed consumption in order to maintain body temperature. The data we report here are the results of a study conducted to evaluate the effect of PST treatment in finishing hogs maintained in a cold environment.

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[1]USDA-Agricultural Research Service, Animal Physiology and Nutrition Unit.
[2]Monsanto Co., St. Louis, MO.
[3]Department of Animal Sciences, UMC.

EXPERIMENTAL PROCEDURES

Twenty-four crossbred (Landrace x York x Duroc) finishing hogs, with an average initial body weight of 187 lb, were used for this study. Four experimental treatments were: 1) thermoneutral (TN) environment of 64 to 68°F with sham placement of implant; 2) TN with hogs receiving PST 100 mg implant (Monsanto Co., St. Louis, MO); 3) cycling cold conditions of 41 to 59° F, with hogs receiving sham placement of implant; and 4) cycling cold conditions, with hogs receiving PST implant. The cold environmental conditions simulated typical cold winter conditions in Missouri. The hogs were housed in the Brody Climatology Laboratory in two chambers which were programmed to maintain the above described environmental conditions.

Hogs were individually penned, fed and watered ad libitum until body weights reached approximately 242 lb. Hogs were fed a corn-soybean meal diet, 12% crude protein with an energy content of 1.49 Mcal/lb. Implants were inserted into the right ear of each hog on day 0. Hogs were slaughtered 28 or 35 days later depending on weight gain.

Hog body weights and feed consumption were determined weekly to assess performance. Respiratory rates and rectal temperatures were measured and used as indicators of thermal balance. At slaughter, one-half of the carcass was used to determine the following carcass characteristics: loin muscle area, weight of leaf fat, first and last rib backfat, length and muscle score. The other half of the carcass was prepared for proximate analysis for protein, fat, ash and moisture content as an estimate of body composition. Energy retained as protein and fat and heat production were estimated from these values.

RESULTS

Cumulative performance for finishing hogs without any PST (control) and those treated with PST and maintained in either a TN or cold environment is shown in Table 1. Hogs in the cold environment gained at a slower rate than those in TN, and this rate was not affected by PST. Control and PST-treated hogs cumulatively had similar feed intakes; however, PST-treated hogs had lower feed intake during the first several weeks (data not shown). Feed intake was less in hogs treated with PST in the cold, but again the differences tended to diminish in the last weeks of the study. Despite the increased feed intake in the hogs treated with PST toward the end of the study, feed/gain ratios reflected greater feed efficiency in the hogs treated with PST in both TN and the cold. The efficiencies overall were better in TN than in the cold.

Carcass characteristics for finishing hogs with or without PST treatment maintained in either a TN or cold environment are shown in Table 2. Finishing hogs in the cold environment tended to have lower final body weights and hot and cold carcass weights. PST-treated hogs had lower last rib backfat and lower amounts of leaf fat. There were no differences in loin muscle areas, first rib backfat and dressing percent.

Assessment of thermal balance of finishing hogs in this experiment is shown in Table 3. PST-treated hogs demonstrated no greater susceptibility to the cold than the control animals. Finishing hogs treated with PST had slightly higher rectal temperatures in both TN and cold environments; however, no significant differences in respiratory rates were found. Overall, hogs in the cold environment had lower rectal temperatures and lower respiratory rates. Estimates from proximate analysis of the carcass showed no differences in net heat production. If heat production and energy retained were evaluated as percentage of metabolized energy, heat production was only slightly higher in PST-treated hogs in either environment; however, energy retained as protein was greater in PST-treated hogs than the controls and to a lesser degree in hogs in the cold environment. Energy retained as fat was less in the PST-treated hogs but overall was similar among hogs in each environment. Moisture content was significantly higher in hogs treated with PST; however, this amount was reduced in the animals in the cold.

DISCUSSION

The results of this study demonstrate that the enhanced performance attributed to treatment with the growth factor PST can be achieved in finishing hogs in a cold environment. We had previously demonstrated enhanced performance in PST-treated finishing hogs in a hot environment, and together these data indicate that PST-treated hogs can respond to the stimulus of the growth factor regardless of thermal stress. The dose and delivery system for PST used in this study had no effect on average daily gain, but did reduce feed consumption and improve feed efficiency. The cold environment caused a reduction in gain and in feed efficiency. No additive effects of the cold environment and PST that were detrimental to performance were found.

The assessment of thermal balance reported in this study suggests that the body composition changes associated with PST treatment did not make the hogs more vulnerable to cold environment. However, it is of interest that the amount of energy retained in the carcass as protein and fat was altered by PST. By estimating energy produced as heat production and retained as protein and fat relative to energy intake from the diet, we were able to assess if energy partitioning is different in the treated and nontreated hogs. The resulting data indicated that hogs treated with PST utilize energy differently. However, this difference was not detrimental to the ability of hogs to thermoregulate and maintain homeothermy, nor to performance or carcass characteristics.

LITERATURE CITED

Curtis, S. E. 1989. Potential side-effects of exogenous somatotropin in pigs. Proc. Biotechnology for Control of Growth and Product Quality in Swine: Implication and Acceptibility. p 155-158.

Table 1. Performance of finishing hogs with (PST) or without (control) treatment of PST and maintained in TN or cold environment.

Parameter	TN		Cold	
	Control	PST	Control	PST
Gain (lb/d)	1.8	2.2	1.5	1.5
Feed intake (lb/d)	7.9	7.7	8.6	7.5
Feed/gain ratio	4.4	3.5	5.7	5.0
Final weight (lb)	249	255	238	244

Table 2. Carcass characteristics for control or PST-treated hogs in TN and cold environments.

Parameter	TN		Cold	
	Control	PST	Control	PST
Hot carcass wt (lb)	181.4	183.2	175.3	176.6
Cold carcass wt (lb)	177.2	179.0	171.3	172.6
Loin muscle area (in^2)	4.7	4.5	4.4	4.3
Carcass length (in)	32.4	32.7	31.5	32.4
Leaf fat (lb)	4.0	3.5	4.4	3.1
First rib backfat (in)	1.8	1.7	1.8	1.6
Last rib backfat (in)	.9	.8	.9	.8
Dressing %	71.5	71.5	72.2	72.7

Table 3. Assessment of thermal balance of finishing hogs with or without (control) PST treatment in either TN or cold environment.

Parameter	TN		Cold	
	Control	PST	Control	PST
Rectal temperature (C)	102.7	103.3	102.4	102.6
Respiratory rate (/m)	36.6	37.0	27.9	25.9
ME intake (Mcal/d)	11.8	11.5	12.9	11.0
Energy retained (Mcal/d):				
as protein	.7	.7	.4	.5
as fat	3.3	2.8	4.0	2.2
Heat production (Mcal/d)	7.8	8.0	8.5	8.4
Moisture in carcass (oz)	12.8	16.8	6.6	11.7

THE IMPORTANCE OF CENTRAL TEST STATIONS AND PERFORMANCE TESTING OF REPLACEMENT SEEDSTOCK

R.O. Bates

Summary

Commercial pork producers were surveyed to determine their perception of central test stations. Of those surveyed 82.6%, used purebred boars but only 59.8% use purebred boars exclusively. Regardless of size, commercial producers wanted growth, carcass and maternal information available when they evaluate prospective herd sire replacements. Over the last five years, only 30.3% had purchased boars from central test stations; however, of those surveyed 68.5% indicated that they wanted their seedstock supplier to participate in central test stations.

Introduction

Central test stations have been in operation for over 30 years with the University of Missouri Test Station operating since 1958. Central test stations provide a public demonstration of uniform testing procedures for growth rate, feed efficiency and backfat thickness. Purebred boars are routinely tested; however, gilts and barrows have been tested on a limited basis. Central test stations also provide a public forum for comparison of seedstock suppliers. However, since only a few pigs per sire and breeder are tested, comparisons among sires of pigs and seedstock firms are difficult to interpret. During the last decade central test stations have struggled to maintain viability. For test stations to remain in operation, they must be able to measure traits that are difficult to measure on the farm and be a part of a total genetic improvement program. Therefore this survey was undertaken to better understand the perception of central test stations among commercial pork producers so to better align central test programs in a genetic improvement scheme.

Methods

This survey was conducted during February, 1990. A twelve question survey instrument was given out during four University Extension meetings. These meetings were located in central, northwest, southwest and south central Missouri. Two of these locations were near central test stations and two were not. Pork producers were asked to complete the survey instrument regardless if they had or had not purchased central test station boars in

the past. Seedstock producers were asked not to participate in this survey.

For analysis purposes, each response to the survey was classified as a large (more that 99 sows), medium (51 to 99 sows) or small (50 or less sows) commercial swine producer. Producers were asked to list the breed makeup of the boars in their inventory. From this boars were classified as purebreds, crossbreds or hybrids. Purebred boars were classified as one of the eight major breeds. Crossbred boars were boars that were listed as crossbreds or of crosses among the eight major breeds. Hybrid boars were boars listed as hybrids or boars from breeding companies. There were 92 surveys completed. The average number of sows listed by respondents was 118 with a range of 8 to 1500. The median number of sows was 75. The average sow to boar ratio was 15.9.

Results and Discussions

Tables are presented which summarize the responses. The title of each table pertains to the question asked and the percentage response for each answer is given. Tables 9-12 summarize the response to four questions by sow herd size.

Of those surveyed, 82.6% use purebred boars (table 1) in their breeding program while of those responding 84% kept more that one breed of boar in their inventory (table 2). When asked to list the breeds or breed crosses in their inventory, it was evident that several types of boars were kept (table 3). Even though 82.6% responded as using purebred boars, only 59.8% were exclusively using purebreds. There was a trend to use both crossbred or hybrid boars in combination with purebreds.

When asked what type of performance information they felt important to choose a replacement herd boar, 85.9% desired growth rate and carcass trait data on the boars (table 4), while 75% also wanted maternal information from female relatives (table 5). Asked when their last purchase was made at a central test station (table 6), only 30.3% had purchased boars from a central test station within the last five years. However, of that 30.3% 68% had purchased boars within the last two years. When asked why they had not recently purchased boars from a central test station (table 7), the single answer most often given was that they would rather purchase boars privately off the farm.

Even though less than one-third of the commercial producers who returned the survey had actually purchased boars from test stations, 68.5% of those surveyed indicated that they wanted their seedstock supplier to participate in central test stations (table 8).

In tables 9 through 12 analyses were conducted to determine if responses given differed by the size of the sow herd the producer was managing. Usage of purebred boars was not significantly different among sow herds of different sizes (table 9); however, there was a trend for larger herds to use more crossbred and hybrid boars.

Little difference existed among producers with differing numbers of sows for their desire to evaluate prospective herd sire replacements with performance records (tables 10 and 11). Pork producers with small, medium and large sow herds overwhelmingly wanted prospective herd boar replacements to be accompanied with performance information for growth rate and carcass traits as well as maternal information on female relatives.

When asked if they wanted their seedstock supplier to participate in central test stations there was a difference of opinion among pork producers with sow herds of differing size (table 12). A large majority of small and medium pork producers wanted their seedstock supplier to participate in central test stations. However, large producers were split almost evenly on this question. There was a trend among the larger producers to use more crossbred and hybrid boars. This can account for a portion of the difference observed among producers of differing herd size, since central test stations routinely test only purebred boars.

Conclusion

Commercial pork producers continue to use purebred boars, with a portion also using crossbred and hybrid boars in conjunction with purebred boars. The majority of commercial producers, regardless of size, wanted growth, carcass and maternal information on female relatives available as they evaluate prospective herd boar replacements. Only 30.3% of those surveyed had actually purchased a boar from a central test station in the last five years. However, 68.5% of those surveyed indicated that they wanted their seedstock supplier to participate in central test stations, with more small and medium size producers indicating this desire. The single reason most often listed for not buying boars at a central test station was producers would rather buy privately off the farm.

Table 1. DO YOU USE PUREBRED BOARS?

YES	NO
82.6%	17.4%

Table 2. HOW MANY BREEDS OF BOARS DO YOU KEEP IN INVENTORY?

No. of Breeds	Percent Response
1	13.0
2	21.7
3	35.9
4	10.9
5	1.1
No response	17.4

Table 3. TYPE OF BOARS USED

Pure-Bred	Cross-Bred	Hybrid	Percent Response
_[a]	-	-	15.2
+	-	-	59.8
-	+	-	4.3
-	-	-	5.4
+	+	-	5.4
+	-	+	7.6
-	+	+	2.2

[a]A "-" indicates no use of this type of boar while a"+" indicates usage of this type of boar.

Table 4. DO YOU FEEL IT NECESSARY THAT YOUR REPLACEMENT HERD BOARS BE TESTED FOR GROWTH AND BACKFAT?

YES	NO
85.9%	14.1%

Table 5. DO YOU FEEL IT NECESSARY THAT YOUR REPLACEMENT HERD BOARS HAVE INFORMATION REGARDING MATERNAL PERFORMANCE OF FEMALE RELATIVES?

YES	NO
75%	25%

Table 6. LAST PURCHASE OF A BOAR FROM A CENTRAL TEST STATION

Answer	Percent Response
In the last year	13.0
In the last 2 years	7.6
In the last 3 years	4.3
In the last 5 years	5.4
In the last 10 years	13.0
Never	56.5

Table 7. REASONS LISTED FOR NOT PURCHASING BOARS FROM A CENTRAL TEST STATION.

Answer	Percent Response
Purchase Privately	16.3
Health	10.9
Number Tested/Breed or Breeder	10.9
Use Hybrid or Crossbred Boars	8.7
Constitution of Boars	3.3
Cost	3.3
Sow Productivity Information	1.1
Other	45.5

Table 8. SHOULD YOUR SEEDSTOCK SUPPLIER PARTICIPATE IN A CENTRAL TEST STATION?

YES	NO
68.5%	30.4%

Table 9. PUREBRED BOAR USE BY SOW HERD SIZE

Sow Herd Size	Percent Response YES	NO
L	75.8	24.2
M	86.7	13.3
S	86.2	13.8

Table 10. PERSPECTIVE HERD BOARS TESTED FOR GROWTH AND CARCASS TRAITS BY SOW HERD SIZE

Sow Herd Size	Percent Response YES	NO
L	81.8	18.2
M	90.0	10.0
S	86.2	13.8

Table 11. PERSPECTIVE HERD BOARS HAVE MATERNAL INFORMATION FROM FEMALE RELATIVES BY SOW HERD SIZE

Sow Herd Size	Percent Response YES	NO
L	69.7	30.3
M	76.7	23.3
S	79.3	20.7

Table 12. SHOULD SEEDSTOCK SUPPLIERS PARTICIPATE IN CENTRAL TEST STATIONS BY SOW HERD SIZE

Sow Herd Size	Percent Response YES	NO
L	54.6	42.4
M	80.0	20.0
S	72.4	27.6

CHEMICAL CASTRATION IN SWINE BY INTRATESTICULAR INJECTION

M.D. Ropp, R.O. Bates, V.K. Ganjam, M.S. Fahim,
H.B. Hedrick and H. Heymann

SUMMARY

Ninety-six Yorkshire sired male pigs were used to determine the effectiveness of a zinc-arginine complex for chemical castration by intratesticular injection. Significant reductions in testicular and epididymal weight were shown in injected boars. Additionally, injected pigs and intact boars were superior in all carcass composition traits compared to knife castrate pigs. However, boar odor was not reduced and often increased in injected groups when compared to intact boars.

INTRODUCTION

The primary objective of this study was to evaluate the effectiveness of a zinc-arginine ph-neutral complex as an intratesticular injection castration agent in swine. Young boars were injected and compared to their intact and knife castrated counterparts in areas of growth performance, hormonal production, carcass composition and sensory panel determination of boar odor. In addition to rendering the animals infertile, it was hoped to reduce testosterone levels sufficiently to eliminate boar taint and yet have sufficient residual levels to maintain some of the positive anabolic effects.

EXPERIMENTAL DESIGN

Three repetitions, each involving 32 male pigs were conducted. Four week old pigs were weighed and randomly assigned to one of four treatment groups. Treatments were intact male pigs (IM), knife castrates (KC), injection in each testis with 50 mg of a zinc-arginine complex delivered in 1/2 ml of solution (50I) and injection with 100 mg of the compound dissolved in 1 ml of solution (100I).

Injections were performed by first cleaning the injection site thoroughly with isopropyl alcohol, then a 1/2 inch 20 gauge needle was inserted near the dorsal end of the testis and ran lengthwise approximately half the length of the testis. This insured that the compound was deposited as near the center of the testis as possible. During proper injection of the solution the testis would swell slightly to the touch. All pigs were returned to the sow. Pigs were reared in pens of eight with two of each treatment per pen from ten weeks of age to market weight. Additionally, blood samples were collected biweekly beginning at 14 weeks. At slaughter (229 $\pm$ 25.0 lbs.), testicular and epididymal weights were taken. Carcass data were collected and fat samples were frozen for sensory analysis.

Serum testosterone levels were determined from the thawed plasma samples using radio-immunoassay techniques. A total of 480 samples were analyzed in a single run. Sensory panel analysis of boar odor, was conducted using eight panelists screened and chosen for their ability to distinguish boar taint in heated fat samples. Each panelist individually scored each fat sample for boar odor perception without prior knowledge to the treatment origin of a particular sample. Samples were scored on a scale of 0 to 9 with 0 being no detectible odor and 9 being a highly objectional level of boar taint.

Results and Discussion

The effect of treatment on performance and carcass traits are illustrated in Table 1. Average daily gain was not significantly different between any of the four groups. Knife castrates were significantly fatter than IM, 50I and 100I ($p<.05$) by 18%, 26% and 18% respectively in average backfat. For tenth rib fat depth the KC were 29%, 42% and 30% fatter than the other treatments respectively ($p<.05$). Additionally, the same three groups had larger loin muscle areas ($p<.05$) by 16%, 18% and 16% respectively than KC and had significantly longer carcasses ($p<.05$) by 3%, 4% and 3%. The lone area of advantage for the KC was in dressing percentage where they had a 3%, 4% and 3% superior value than IM, 50I and 100I pigs. Testicular and epididymal weights were compared (Table 2) and significant differences were found between IM and 100I pigs for total testicular weight (TTW) with a 34% reduction in size ($p<.05$) in the 100I group. A linear dosage relationship for TTW was also found between IM, 50I and 100I ($p<.05$). Epididymal weights were reduced ($p<.05$) in 50I and 100I treatments by 26% and 45% when compared to IM. Again a linear dosage response was significant ($p<.05$) across these three groups. Radio-immunoassay for testosterone showed no significant difference between IM, 50I and 100I values for any of the five biweekly measurements though a trend toward lower testosterone values for 100I compared to IM at T4 and T5 was apparent (Table 3). There was however a trend toward significance at bleeding four ($p<.11$) and five ($p<.1$) between these treatments. KC pigs had only one small, non-zero value at the sensitivity of this assay. The data collected from the sensory panel analysis for boar odor was somewhat surprising (table 4). As expected the mean scores for KC were significantly lower ($p<.05$) than for IM, 50I and 100I samples by 53%, 96% and 86% respectively. However, mean scores for IM were also significantly less than for 50I and 100I samples ($p<.05$).

Subjective observations of the chemically castrated pigs were as follows. Shortly after injection, swelling could be noticed in the testes of all individuals. This swelling, to about twice normal size persisted for approximately one week but appeared to cause the animals no obvious discomfort. As animals developed it became apparent that even though testicular growth was occurring at a pace similar to the IM pigs, the development was quite variable in size and shape even between the testes on the same animal. Testicular development ranged from almost an abnormal over growth appearance to testicles that were barely visible. These external

abnormalities were confirmed upon removal at slaughter with tissue damage being evident. Boar sexual behavior was also observed. There was a great deal of sexual aggressiveness in the treatment pens. This behavior was evident among the IM, 50I and to a lesser extent the 100I pigs. KC pigs as expected showed no sexual aggressiveness.

Conclusions

Zinc-Arginine is an effective injectable chemical sterilant in swine for simply rendering the animal incapable of producing live, viable sperm. However, at the treatment age and level of injection used in this study, there was not a significant reduction in either testosterone production nor more importantly in the level of boar taint in the fat samples tested. The linear dose responses in testicular and epididymal weight are encouraging that a higher dose or a younger age of injection may be more effective in achieving the boar taint reductions sought in this study.

Table 1. PERFORMANCE AND CARCASS MEASURES

	LS Means Treatment Groups			
Trait	IM	KC	50I	100I
Number	24	24	23	23
ADG (lb/day)	1.50 ± .034	1.53 ± .035	1.48 ± .035	1.49 ± .034
% Dress	71.7ab± .003	73.0b ± .003	71.0c ± .003	71.3ab± .003
Length (in)	31.2a ± .127	30.6b ± .132	31.5a ± .138	31.2a ± .128
Avg BF (in)	1.42a ± .022	1.69b ± .023	1.35a ± .024	1.43a ± .022
TR BF (in)	1.41a ± .043	1.82b ± .045	1.28a ± .046	1.40a ± .043
LMA (in2)	4.27a ± .081	3.69b ± .086	4.34a ± .089	4.26a ± .081

[a,b,c] Means within a row with different labels differ ($p<.05$).

Table 2. TESTICULAR PARAMETERS

	LS Means	
Treatment	Total Testicular Wt (g)	Total Epididymal Wt (g)
IM	548.8a ± 30.7	115.0a ± 4.8
50I	488.7ab ± 33.1	91.2b ± 5.1
100I	408.7bc ± 30.6	79.1bc ± 4.8

a,b,c Means within a row with different labels differ ($p<.05$).

Table 3. SERUM TESTOSTERONE LEVELS

	LS Means Serum Levels (ng/ml), Biweekly Measurement				
Treatment	T1	T2	T3	T4	T5
IM	2.54	3.99	5.47	5.14	5.95
KC	0.0	0.0	0.0	0.0	0.0
50I	3.23	3.83	4.87	5.80	4.07
100I	2.40	2.35	3.75	2.31	3.50

Table 4. SENSORY PANEL ANALYSIS OF BOAR ODOR

Treatment	LS Mean Boar Odor Score
IM	4.69 a ± .12
KC	3.07 b ± .11
50I	6.01 c ± .12
100I	5.70 c ± .12

a,b,c Means within a column with different labels differ ($p<.05$).

RESPONSES TO SELECTION FOR INCREASED SUPEROVULATION RATE IN SWINE

G. R. Eckardt, W. R. Lamberson and B.N. Day

SUMMARY

A study was conducted to evaluate selection for increased superovulation rate as a method to increase litter size in swine. Response to selection was analyzed utilizing new statistical methods to calculate estimated breeding values. After four generations of selection, estimated breeding values for litter size increased. This method of selection cannot be recommended as responses to selection are likely to be variable.

INTRODUCTION

The overall efficiency of swine production could be increased through improvement of reproductive efficiency (Tess et al., 1983). Several attempts to increase litter size in swine have had mixed success. Researchers at the University of Nebraska selected for increased natural ovulation rate for nine generations and estimated heritability to be .42 ± .06 but did not observe any changes in litter size (Cunningham et al., 1979). Further investigations indicated moderate response to selection for litter size in swine that had previously been selected for increased ovulation rate (Lamberson et al., 1991). Nebraska researchers also reported moderate response in litter size of gilts selected on an index of ovulation rate and embryo survival (Neal et al., 1989).

Lamberson and Day (1986, University of Missouri-Columbia) reported an attempt to increase reproductive efficiency by administering exogenous hormones to superovulate females. Analysis of response to selection in that study using new statistical methods to calculate estimated breeding values (EBV) was the purpose of this project.

PROCEDURES

Two lines were formed by randomly assigning Hampshire-Yorkshire crossbred gilts from a rotational crossbreeding scheme to a randomly selected line (R-line) or a line selected for increased superovulation rate (S-line). All gilts were administered methallibure in the ration for 20 d to synchronize estrus. Select line gilts were superovulated via a 1500 IU subcutaneous injection of pregnant mare serum gonadotropin one day after the withdrawal of methallibure. All gilts were artificially inseminated with 100 ml of semen from a single boar from an unrelated herd each generation. Laparotomies to evaluate natural ovulation rate (NOR) for R-line females and superovulation rate (SOR) for S-line females were performed 4 to 6 d after insemination. All gilts were allowed to farrow. Approximately 40 gilts were measured in each line each generation. Fifteen replacement gilts were randomly selected in the R-line. Select line replacement gilts were those 15 gilts having the largest SOR of those which subsequently farrowed. Generation interval was one year. Second and third parity ovulation rate and litter size were measured on a random sample of females in both lines during generations 0 to 3. Selection was practiced for four generations. Generation 4 gilts in the S-line were randomly assigned to be superovulated and SOR measured as in generations 0 to 3 or to be treated as were the R-line gilts

and NOR measured. Generation 4 gilts in the R-line were randomly assigned to have NOR measured or to be superovulated and SOR measured.

Natural ovulation rate and SOR must be considered separate traits, therefore, this selection experiment has no true control line. Estimated breeding values of animals were calculated using new statistical methods (Tess, 1989).

Estimated breeding values of NOR were calculated for females in the R-line while EBV of SOR were calculated for females in the S-line. Estimated breeding values for litter size were calculated for both lines. Realized heritability was calculated by regressing generation mean EBV on the cumulative selection differential.

RESULTS AND DISCUSSION

Estimated breeding values of S-line females for SOR increased over the four generations (Figure 1). Estimated breeding values for SOR increased .16 ± .05 units per generation in the S-line. The heritability of SOR at first parity estimated by doubling the regression of daughter or dam in the present study was .16 ± .22. Regressing the generation mean EBV of SOR on the cumulative selection differential to estimate heritability was .06 ± .02. These estimates were lower than those reported for NOR by researchers at the University of Nebraska. They reported a heritability estimate of .42 ± .06 for a line of pigs selected n en generations for increased NOR.

Correlated changes in EBV for litter size in the S-line was .16 ± .06 pigs per generation (Figure 2). However, EBV for litter size in the R-line increased at a rate of .11 ± .06 pigs per generation.

Means for NOR, SOR and LS are presented in Table 1. Although genetic improvement in litter size occurred, responses are likely to be variable and this method of selection cannot be recommended as a practical means to improve litter size.

LITERATURE CITED

Cunningham, P.J., M.E. England, L.D. Young and D.R. Zimmerman. 1979. Selection for ovulation rate in swine: Correlated response in litter size and weight. J. Anim. Sci. 48:509-516.

Lamberson, W.L. and B.N. Day. 1986. Response to selection for increased superovulation rate in swine. IN: G.E. Dickerson and R.K. Johnson (Ed.) Proc. 3rd World Congress on Genetics Applied to Livestock Production, July 16-22, Vol. XI:249-253, University of Nebraska, Lincoln.

Lamberson, W.R., R.K. Johnson, D.R. Zimmerman and T.E. Long. 1991. Direct responses from selection for increased litter size, decreased age at puberty or relaxed selection following selection for ovulation rate in swine. J. Anim. Sci. (In Press).

Neal, S.M., R.J. Johnson and R.J. Kittok. 1989. Index selection for components of litter size in swine: Response to five generations of selection. J. Anim. Sci. 67:1933-1945.

Tess, M.W. 1989. Documentation for "Animal Models." Montana State University (Mimeo).

Tess, M.W., G.L. Bennett and G.E. Dickerson. 1983. Simulation of genetic changes in life cycle efficiency of pork production. II. Effects of components on efficiency. J. Anim. Sci. 56:354–368.

TABLE 1. LINE–GENERATION–PARITY MEANS AND STANDARD DEVIATIONS FOR SUPEROVULATION RATE, NATURAL OVULATION RATE AND LITTER SIZE.

		Select line						Random line					
		Superovulation rate			Litter size			Natural ovulation rate			Litter size		
Generation	Parity	n	x	s	n	x	s	n	x	s	n	x	s
0	1	38	19.5	8.4	28	9.4	2.8	41	12.9	2.4	33	9.1	3.1
	2				26	10.5	3.0				25	10.6	3.1
	3	12	18.9	6.7				10	17.5	1.7			
1	1	38	17.7	10.1	26	7.9	3.5	40	12.0	2.3	34	8.8	3.4
	2	29	20.5	7.1	16	9.3	3.4	31	16.2	4.0	26	9.5	2.9
	3	19	17.9	4.7				27	17.0	3.5			
2	1	36	22.0	7.7	20	10.0	4.0	40	13.5	2.2	23	9.4	3.0
	2	20	17.7	9.1	10	11.5	4.1	21	13.9	3.6	4	8.8	1.3
	3	6	16.8	4.4				7	15.3	4.7			
3	1	41	26.6	14.5	34	11.6	2.9	36	14.0	2.9	29	10.0	2.6
	2	11	16.9	8.8	2	11.0	7.1	10	15.0	6.0	9	10.4	7.3
	3	14	25.9	8.0				9	18.6	2.5			
4	1	16	21.3	11.1	10	9.6	3.8	22	13.3	2.6	17	9.7	2.6
4[a]	1	22	12.0	2.1	15	9.9	2.1	20	26.2	10.9	13	11.5	2.6

[a]Natural ovulation rate of random sample of the select line and superovulation rate of random sample of the random line.

Figure 1. Mean Estimated Breeding Values for Superovulation Rate by Generation for S-line.

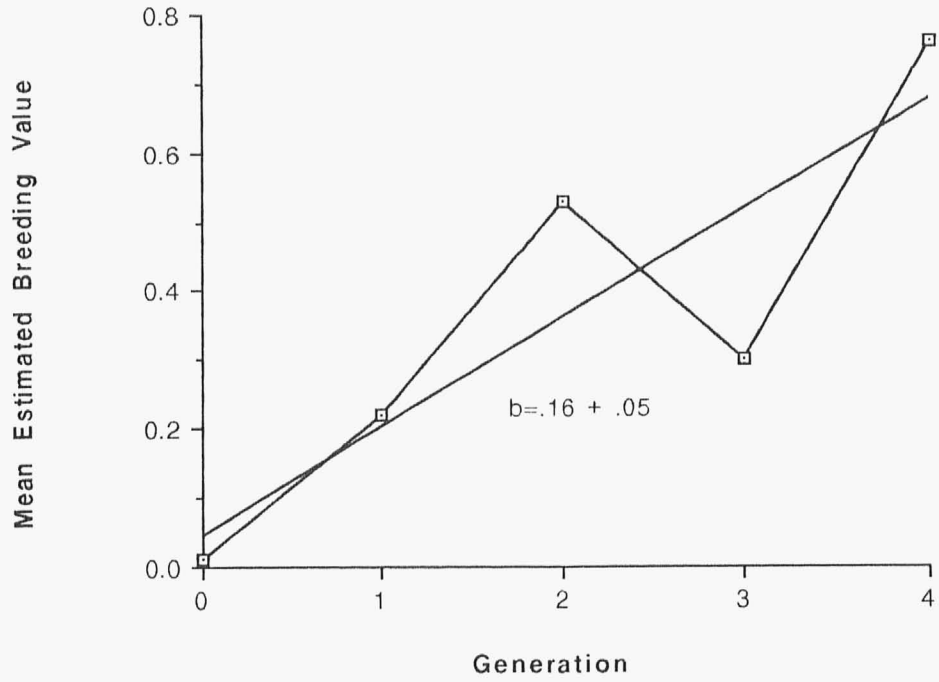
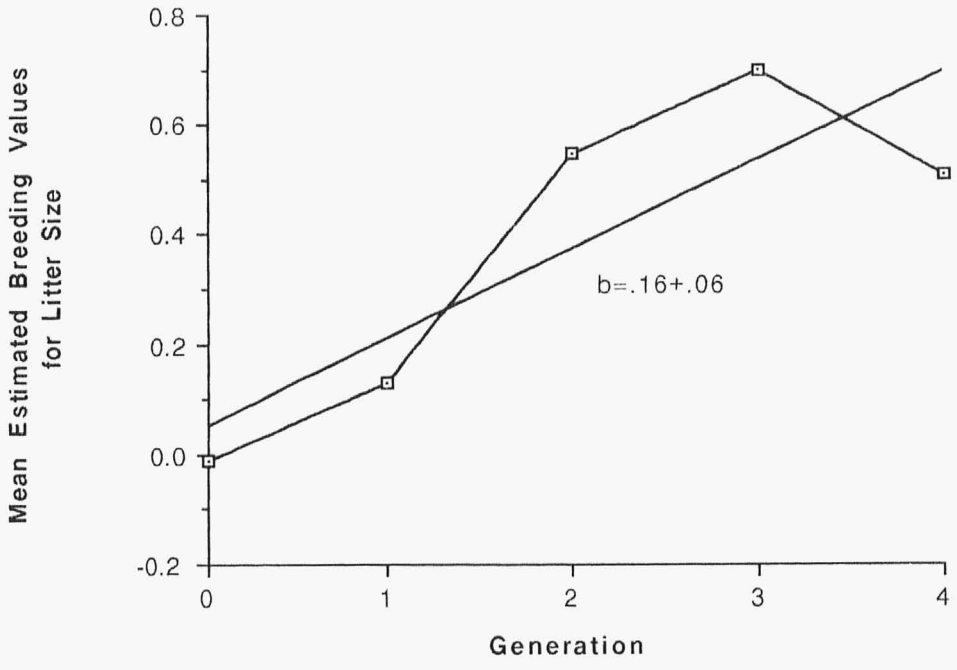


Figure 2. Mean Estimated Breeding Values for Litter Size by Generation for S-line.



EFFECT OF RIBOFLAVIN SUPPLEMENTATION DURING GESTATION ON REPRODUCTIVE PERFORMANCE OF SOWS.

S.L. Tilton, R.O. Bates and R.J. Moffatt

SUMMARY

The study used 151 sows to determine if feeding supplemental riboflavin during the first 12 days after breeding affected the number of live pigs born per litter. After breeding, sows were fed either the normal gestation ration, or one with an extra 90 to 100 mg of riboflavin per day. No differences were seen in the number of live pigs born, stillborns or litter birth weight between control sows and those receiving supplemental riboflavin. It appears that it is unnecessary to supplement sow gestation diets with riboflavin levels above NRC recommendations during the early part of gestation.

INTRODUCTION

The number of live pigs born is an extremely important economic factor in swine production; therefore, research is constantly being conducted to improve the number of live pigs born per litter. It has been shown that feeding supplemental riboflavin to gilts between days 6 and 8 of gestation results in a 1.1 pig increase in live pigs born per litter (Bazer and Zavy, 1988). In addition, 80.4% of the riboflavin treated gilts farrowed as compared to 70.8% of control gilts. This study was then conducted to determine if riboflavin supplementation above NRC recommendations in sows for the first 12 days after breeding also resulted in increased number of live offspring per litter.

MATERIALS AND METHODS

This study was designed to compare the current University of Missouri Swine Research Center's gestation diet with the same diet supplemented with 40 g of riboflavin per ton (see Table 1). Sows were fed between 4.5 and 5.0 pounds of feed per day, resulting in the intake of an additional 90 to 100 mg of riboflavin for treated sows.

The study began on February 16, 1989 and concluded on March 1, 1990, when the last treated sow was weaned. One hundred fifty-one sows were used, with 111 of these sows farrowing. Females were randomly allotted to diet within parity. Parity was designated as sows that had weaned their first litter, sows that had weaned their second litter and those that had weaned three or more litters. Data collected included information on number of pigs born, number weaned, birth weight and weaning weight.

RESULTS

Results are shown in Table 2. This study showed that when sows were fed riboflavin above NRC recommendations during early gestation there was no difference in the number of live pigs born per litter. There was also no difference in the percentage of sows farrowing and the percentage of sows that were rebred. In addition, no difference was seen in the number of stillborns and litter birth weight. These results are also supported by a 281 sow/gilt study, showing no difference in these categories (Luce et al., 1990).

CONCLUSION

The results of this study indicate that it is not beneficial to over fortify sow diets with riboflavin during early gestation; although, further research needs to be done to determine if it is beneficial for gilts.

LITERATURE CITED

Bazer, F.W. and M.T. Zavy. 1988. Supplemental riboflavin and reproductive performance of gilts. J. Anim. Sci. 66 (Suppl. 1):324 (Abstr.).

Luce, W.G., R.D. Geisert, M.T. Zavy, A.C. Clutter, F.W. Bazer, C.V. Maxwell, M.D. Woltmann, R.M. Blair, M. Fairchild and J. Wilford. 1990. Effect of riboflavin supplementation on reproductive performance of bred sows. Okla. St. Anim. Sci. Res. Rep. p. 269.

Table 1. COMPOSITION AND NUTRIENT CONTENT OF SOW GESTATION DIET.

Ingredient	Control diet
Shelled Corn	80.8%
44% Soybean Meal	13.0%
Dical	2.6%
Lard	2.0%
Trace Mineral Mix	0.5%
Vitamin Mix	0.5%
Salt	0.5%
Limestone	0.1%

CRITERIA	NUTRIENT CONTENT
Net energy kcal/lb	1516.99
Crude protein	13.0%
Calcium	.90%
Phosphorus (available)	.61%
Lysine	.65%

Table 2. LEAST SQUARE MEANS OF SOW PERFORMANCE.

Criteria	Control	Riboflavin
Sows/treatment	51	60
Percent farrowing,%	65.57	72.48
Percent rebred,%	17.42	12.93
Pigs born alive	10.42	10.40
Stillbirths	.67	.77
Litter birth weight,lbs.	36.7	35.9
Pigs weaned	9.26	9.18
Litter weaning weight,lbs.	144.1	145.0

EFFECT OF MATERNAL FAT SOURCE ON PIGLET IMMUNE CELL FATTY ACID COMPOSITION AND PROSTAGLANDIN E_2 (PGE_2) PRODUCTION.

D.W. Alexander, S.C. Huang, N.A. Cassity, K.L. Fritsche

SUMMARY

To determine to what extent omega-3 (n-3) fatty acids are incorporated into the immune cells of piglets nursing fish oil-fed sows we conducted the following experiment. On day 107 of gestation 12 sows were randomly allotted to a diet containing 7% fish (menhaden) oil (FO) or lard (LA). Two representative piglets (18-21d of age) from each litter were sacrificed and serum, liver, thymus, spleen, alveolar macrophage (AM) cells, and peritoneal exudate cells (PEC) were collected. Samples were analyzed for fatty acid content. In addition, the effect of n-3 enrichment on PGE_2 production was assessed in AM and PEC samples stimulated with lipopolysaccharide (LPS; 2.5 ug/ml) or calcium ionophore A23187 (1 uM). The fatty acid profile of serum and tissues of piglets was significantly effected by the fat source provided to the sow. Arachidonic acid (AA=20:4n-6) levels were typically 2-3 fold lower ($p < 0.0001$) in FO vs. LA piglets. Levels of eicosapentaenoic acid (EPA=20:5n-3), the major n-3 fatty acid, in the blood and tissues were 50 to 150 times greater ($p < 0.0001$) in FO vs. LA piglets. PGE_2 production by AM was 70% lower in FO vs. LA pigs (1491 to 435 pg/0.1ml; $p < 0.02$) when stimulated with LPS. PGE_2 production by PEC was 50% lower in FO vs. LA pigs (1245 vs. 2902 pg/0.1ml; $p < 0.08$) when stimulated with A23187. In conclusion, substituting FO for LA in a sow's late-gestation and lactation diet greatly elevates the content of n-3 fatty acids in the nursing pig and reduces the PGE_2 synthesizing capacity of their immune cells.

INTRODUCTION

In the field of human nutrition there has been a lot of interest in the possible health benefits associated with consuming greater amounts of omega-3 (n-3) fatty acids. Over the last decade researchers have become increasingly interested in the possible health benifits, such as reduced risk for coronary heart disease, cancer, inflammation, associated with the consumption of fish and fish oils. These benefits have been attributed primarily to the n-3 fatty acids present in fish oils. A major area of research involves the immunologic effects of n-3 fatty acids. A common approach is to examine changes in inflammation and immune responses following changes in the dietary lipid composition. To date most research in this area involves laboratory animal experimentation and humans clinical trials. Little attention has been given to the possible beneficial effects inclusion of n-3 rich oils might have in domestic animal production.

Our hypothesis is that the transfer of n-3 PUFA from fish oil-fed sows to the nursing piglet will be of sufficient magnitude to significantly elevate n-3 PUFA levels in immune tissues/cells and this will result in a significant reduction in PG production by these same tissues/cells. Therefore, the specific objectives of this research are as follows: First, to determine the extent to which n-3 fatty acids are incorporated into the immune tissues/cells of piglets nuring fish oil-fed sows. Second, to quantitate the reduction in PG production by immune cells in these piglets.

EXPERIMENTAL PROCEDURE

Animals and Diets:

On day 107 of gestation 12 sows were randomly allotted to one of two diets, in which menhaden oil (FO) was substituted for lard (LA) at 7% of the diet. Composition of diets and fats is shown in Table 1.

Sample Collection

At 3 weeks of age 2 piglets from each litter were sacrificed for tissue collection. The piglets were anesthetized with ketamine (20 mg/kg) and acepromazine (1 mg/kg). Blood (20 ml) was collected and left to clot for serum lipid analysis. The peritoneal cavity was infused with 300 ml of ice-cold Ca^{++}/Mg^{++} free Hank's balanced salt solution (HBSS w/o) for the collection of peritoneal exudates cells (PEC). The abdomen was massaged for two minutes and HBSS was removed (recovery ~ 150-200 ml) and placed on ice. A portion of the spleen was removed and splenocytes were isolated then frozen. Samples of the liver and thymus were snap frozen in 20 ml glass vials using a dry ice-acetone bath. All samples were stored at -80°C until lipid analysis. For the collection of alveolar macrophages (AM) the trachea was clamped off, and the lungs were removed. The lungs were filled with 60 ml of ice cold HBSS w/o and gently shaken. The contents of the lungs were then poured out and filtered through sterile gauze into 50 ml tubes on ice. This process was repeated 2 times (recovery ~100 ml).

Macrophage Purification and PG Production:

The tubes containing the PEC and AM were spun down (500g for 15 minutes) and washed twice with HBSS w/o. The cells were then spun at 500g for 10 min and resuspended in 10ml RPMI-1640 with 2mM L-glutamine, 10mM HEPES, pencillin/streptomycin, pH 7.4 (RPMI-c). Cells were enumerated with a Coulter Counter and resuspended at a final concentration of $5.0x10^6$ cell/ml of RPMI-c. To each well of a 24 well cell culture plate, 0.5ml of PEC or AM were added in addition to RPMI-c 10% autogolous serum. Plates were placed in an incubator at 37°C with 5% CO_2 for 4 hours to adhere the cells. The plates were washed 3 times with RPMI-c (rm. temp), then RPMI-c with 10% autogolous serum was added to the culture plates at 0.5ml per well. Then 0.5ml/well of LPS (5ug/ml) or ionophore 23187 (2ug/ml) was added to stimulate PGE_2 production. Plates were incubated for 4 or 24 hr, then supernantants were collected, spun (10,000 rpm, 3 min.), and stored (-80°C).

Lipid Extraction and Analysis:

Lipids were extracted from the serum, liver, thymus, splenocytes, and alveolar macrophages following homogenation with 8 volumes of chloroform:methanol (2:1). The organic phase containing the lipid extract was collected and reduced under N_2 . Methyl esters of fatty acids were prepared by transmethylation using 4% H_2SO_4 in methanol. Fatty acid methyl esters were identified using a Hewlett Packard gas chromatograph (Sunnyvale, CA), Model 5890Awith a 30m capillary column. Results, expressed as percent of total fatty acids, were determined using a Hewlett Packard 3396A integrator.

Prostaglandin E2 Analysis:

PGE_2 production by AM and PEC was determined with a commercially available enzyme immunoassay kit (Advanced Magnetics Inc., Boston, MA). Cell supernatants were assayed undiluted. The linear portion of a typical standard curves ranged from 2000 to 2.7 pg/0.1 ml.

Statistical Analysis:

Fatty acid data were subjected to one-way analysis of variance (ANOVA) to test for an effect of fat source. PGE_2 data were analyzed by a four factor ANOVA, where main effects included: fat source (LA vs. FO), stimuli (control, ionophore, LPS), time (4 vs. 24 hr.), cell source (alveolar vs.

peritoneal). When significant differences occurred ($P < 0.05$), treatment mean differences wer identified by Fisher's LSD and Scheffe's F-test. All analysis were conducted on a Macintosh II computer using version 1.03 of StatView II (Abacus Concepts, Inc., Berkeley, CA).

RESULTS

The substitution of fish oil (FO) for lard (LA) in the late gestation and lactation diet of sows significantly modified the fatty acid profile of the serum and tissues of nursing piglets. Interestingly, while the two fat sources differed significantly in the amount of saturated (SAT) and polyunsaturated fatty acids (PUFA) there was little difference in the total SAT or PUFA content in the serum or tissues examined (see **Table 2**). However, the relative levels of individual fatty acids, particularly n-6 and n-3 fatty acids, were dramatically altered. For example, the relative levels of arachidonic acid (20:4n-6) were decreased 2-3 fold ($p < 0.0001$) in FO vs. LA piglets (see **Figure 1**). FO-feeding increased the amount of eicosapentaenoic acid (20:5n-3) in the tissues by 50-150 fold ($p < 0.0001$; see **Figure 2**).

Prostaglandin E_2 (PGE_2) production in alveolar macrophages (AM) stimulated by LPS was 70% lower (435 to 1491 pg/0.1ml; $p < 0.02$) and in peritoneal exudate cells (PEC) was 50% lower (1245 vs. 2902 pg/0.1ml; $p < 0.08$) when stimulated with ionophore A23187 in FO vs. LA piglets (see **Figures 3 and 4**).

CONCLUSION

We believe our data supports our hypothesis and conclude that the transfer of n-3 PUFA from fish oil-fed sows to the nursing piglet is of sufficient magnitude to significantly elevate n-3 PUFA levels in immune tissues/cells which leads to a significant reduction in PG production by these same tissues/cells.

Since PG are thought to play a critical role in an animal's response to various pathological challenges, we believe that the inclusion of fish oil in the lactation diet of sows will modify the humoral and cellular immune responses in nursing piglets. We plan to test this hypothesis in future studies.

ACKNOWLEDGEMENTS

Financial support for this research was provided by Missouri Pork Producer's Association, Food for the 21st Century Nutrition Cluster, and the University of Missouri Agriculture Experiment Station.

TABLE 1: Diet composition

Ingredient	% by weight
Corn	58.9
Soybean meal (44%)	20.0
Oats	10.1
Fat*	7.0
DiCalcium Phosphate	2.7
UMC Vitamin Mix	0.5
UMC Trace Mineral Mix	0.5
Ground Limestone	0.4

*Fatty Acid Composition of Fat Sources

	SAT			MONO			PUFA	
	14:0	16:0	18:0	16:1	18:1	18:2	20:5n-3	22:6n-3
LA:	1.3	25.4	13.7	2.8	42.3	10.8	-	-
FO:	6.4	16.6	2.6	10.4	13.9	1.5	14.3	12.6

TABLE 2. Average weight percent of total saturated (SAT), monounsaturated (MONO), and polyunsaturated (PUFA) fatty acids of serum, liver, thymus, splenocytes, and alveolar macrophages from 3-4 wk old piglets nursing sows fed diets containing 7% lard (LA) or fish oil (FO).[1]

Fat Source:	LA	FO		
	(wt %)[2]		SEM[3]	P value[4]
		Serum		
Σ SAT[5]	31.1	28.3	1.6	NS
Σ MONO[6]	29.4	19.0	1.7	.005
Σ PUFA[7]	37.1	49.5	2.0	.001
Σ N-6 [8]	34.0	24.0	1.3	.0005
Σ N-3 [9]	2.8	25.5	2.4	.0001
		Liver		
Σ SAT	32.1	33.8	1.4	NS
Σ MONO	17.7	10.7	.8	.0001
Σ PUFA	47.0	52.5	1.6	.05
Σ N-6	39.9	20.1	2.1	.0001
Σ N-3	6.9	32.3	1.8	.0001
		Thymus		
Σ SAT	36.4	38.9	1.8	NS
Σ MONO	26.8	21.2	1.5	.05
Σ PUFA	32.6	35.0	2.1	NS
Σ N-6	30.3	19.2	1.2	.0001
Σ N-3	3.0	16.2	1.4	.0001
		Splenocytes		
Σ SAT	39.1	35.9	2.3	NS
Σ MONO	18.9	16.5	1.0	NS
Σ PUFA	37.5	43.4	2.9	NS
Σ N-6	32.4	19.0	2.4	0.005
Σ N-3	4.6	24.1	1.3	0.0001
		Alveolar macrophages		
Σ SAT	45.3	47.2	1.2	NS
Σ MONO	18.5	15.0	1.1	.05
Σ PUFA	31.9	33.8	1.4	NS
Σ N-6	26.3	11.6	1.0	.0001
Σ N-3	5.3	22.1	1.1	.0001

[1] Sows were fed diets containing 7% by weight lard (LA) or a fish (menhaden) oil(FO) for 1 week prior to farrowing. Piglets nursed sows within the same treatment group. Samples were collected from pigs upon weaning (3-4 wk).

[2] Values are expressed as means (n=6).

[3] Pooled SEM.

[4] As determined by ANOVA; NS = not significant ($P > 0.10$).

[5] Sum total area percentage of 14:0, 16:0, and 18:0.

[6] Sum total area percentage of 16:1, 18:1, 20:1.

[7] Sum total area percentage of 18:2n6, 18:3n6, 18:3n3, 20:2n6, 20:3n6, 20:4n6, 20:5n3, 22:4n6, 22:5n6, 22:5n3, 22:6n3.

[8] Sum total area percentage of 18:2n6, 18:3n6, 20:2n6, 20:3n6, 20:4n6, 22:4n6, 22:5n6.

[9] Sum total area percentage of 18:3n3, 20:5n3, 22:5n3, 22:6n3.

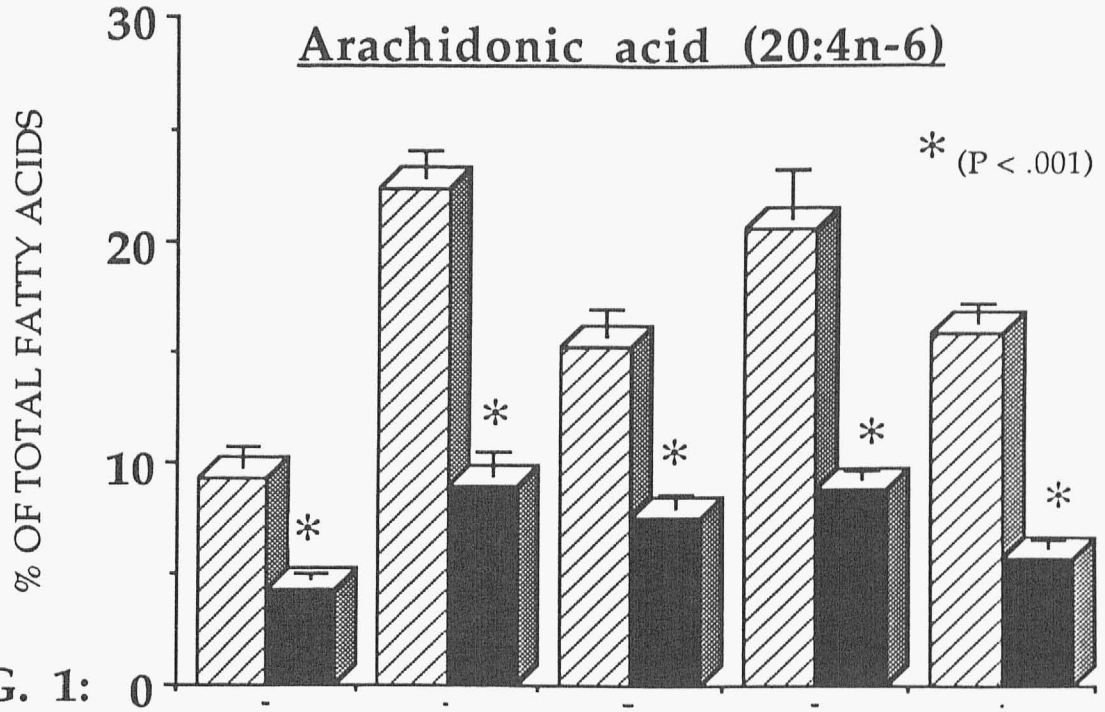


FIG. 1:

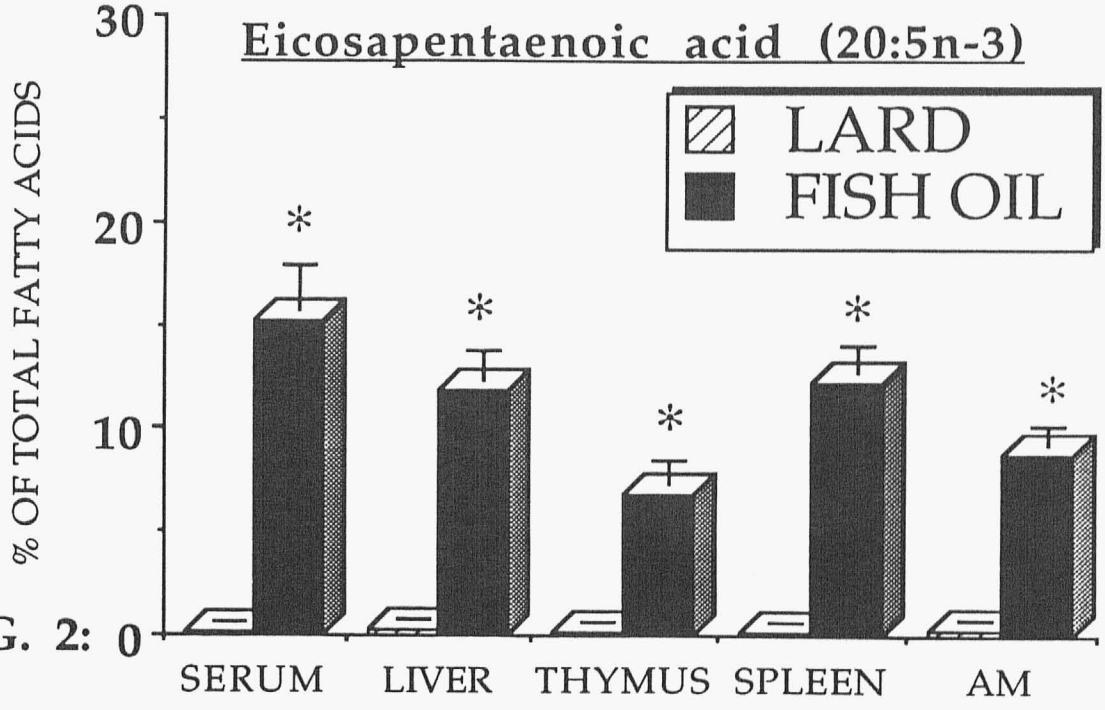


FIG. 2:

FIGURE 1 & 2. Effect of substituting fish oil for lard in sow diets on the percentage of arachidonic acid (20:4n-6) and eicosapentaenoic acid (20:5n-3) in the serum and tissues of piglets. Serum and tissue samples were collected from pigs sacrificed at 3 wks of age. Total lipids were extracted and the fatty acids were analyzed by GLC as described in the methods. Data represents the mean ± S.E.M. (n=6) weight % of the fatty acid indicated. "Spleen" and "AM" samples represent the isolated splenocytes and alveolar macrophages, respectively.

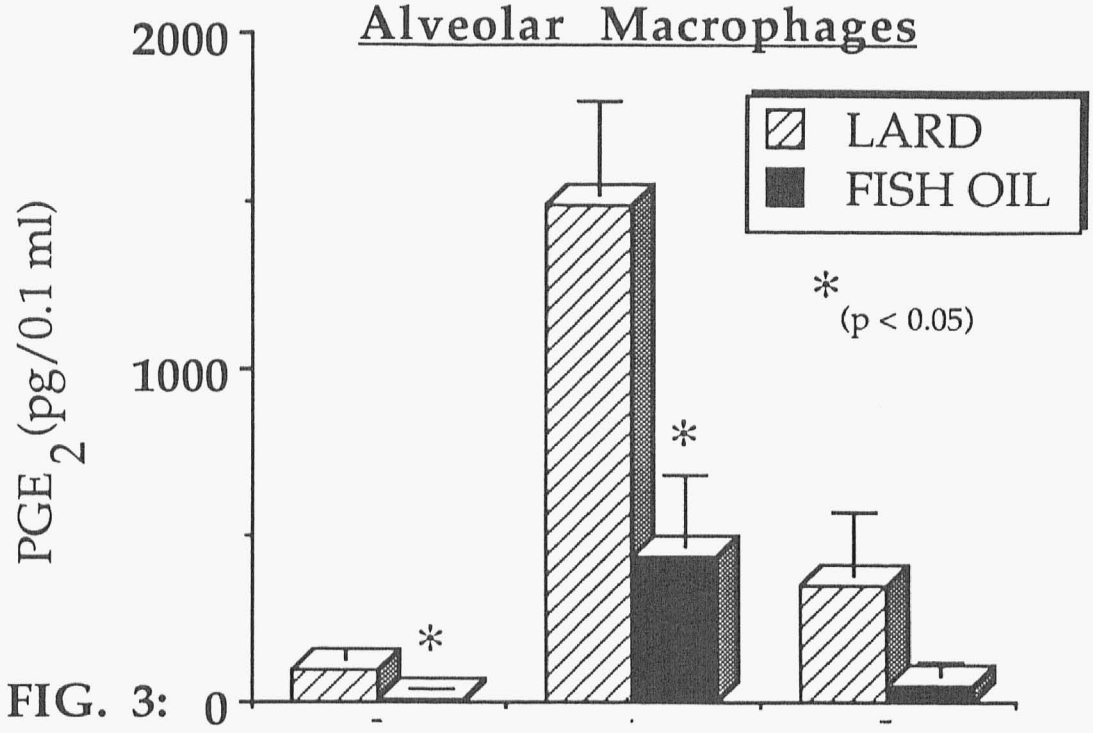


FIG. 3:

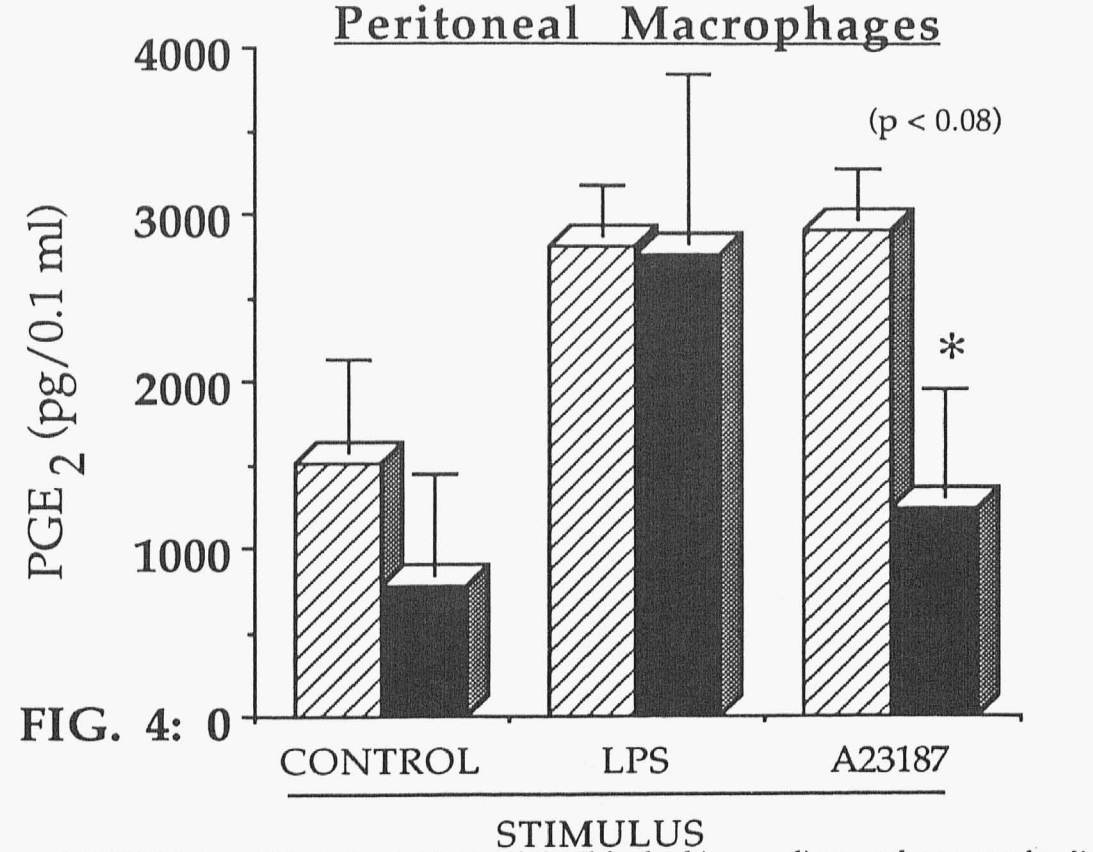


FIG. 4:

FIGURE 3 & 4. Effect of substituting fish oil for lard in sow diets on the prostaglandin E_2 (PGE_2) production by piglet immune cells. Alveolar macrophages or peritoneal exudate cells (5.0×10^6 cell/well) were stimulated with LPS (2.5 ug/ml) or ionophore A23187 (1.9 uM) for 24 and 4 hr., respectively. PGE_2 concentrations in the supernatant were measured by enzyme immunoassay (EIA). Data represents the mean ± S.E.M. (n=6).

PORK PRODUCT RESEARCH (ABSTRACTS)

Department of Food Science and Nutrition
University of Missouri

I. Effect of alternate heat processing parameters on the moisture, lipid content, and fatty acid profile of a restructured pork/soy hull product.

C.A. Schaffer

Three convective heat processing parameters of battered and nonbattered restructured pork/soy hull products were investigated for their effects on moisture, lipids and fatty acids. Three oven temperatures, 204 C, 232 C and 260 C, were used to heat process products to 76 C. Standard methods of chemical analyses were used; saturated and unsaturated fatty acids were analyzed with GC/MS procedures. Samples were taken from both the crust and internal portions. After heat processing, product yields ranged from 62 - 76%; moisture, 59.2 - 67.1%; and lipids, 9.9 - 12.7%. Myristic acid was the predominate saturated fatty acid with ranges from 356 - 1,266 ppm. Arachidonic acid was the predominate unsaturated fatty acid, ranging from 1,521 - 3,171 ppm. Oleic acid contents differed between the crust and internal portions of the samples. Oven temperatures of 260 C lead to variable fatty acid profiles. Further data analyses are in progress.

II. Cultivars of soy hulls affect moisture and lipid contents of restructured pork/soy hull products after heat processing.

N. Unklesbay, Z. Helsel and K. Unklesbay

Five cultivars of soy hulls were examined for their moisture absorbing properties and their effect on product yield, moisture and lipid content when incorporated with pork tissue. A rotating hot air system Rair^{R} was used for heat processing 20 different formulas. The moisture absorbing abilities of the cultivars ranged from 4.76 to 7.05 g water/g dry soy hull. After heat processing, product yields ranged from 63.9 to 74.9%; moisture (%), 61.2 to 70.2%; and lipids (%), 4.2 to 7.5%. Implications about the effect of different cultivars of plants in new menu items were given for catering managers.

III. Formulating pork/soy hull products to reduce lipid and food energy content.

N. Unklesbay, Z.R. Helsel and K. Unklesbay

Having potential nutritional value as a dietary fiber source for consumers, soy hulls were restructured with pork. Sixteen formulae of restructured pork and soy hulls, ranging in moisture content form 74 to 85%, were heat processed to 77 C in a rotating hot air system. Standard procedures were used to determine product yield, moisture (%), lipids (%), food energy, and texture (force g). Both unprocessed soy hulls, and those that had been processed to reduce their lignin content were used, at two different particle sizes. Final moisture (%) levels ranged from 60 to 70; lipids (%), 5.1 to 9.0; food energy (kcal/100 g; wet basis), 182 to 257; and texture (force g), 1,414 to 2,968. By selecting products made from these formulae, consumers could choose pork products with less lipid and calorie contents, compared to pork tissue alone. The consumption of dietary fiber is another nutritional benefit of these products.

NEW PROGRAMS IN SWINE HEALTH

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Summary

Basic approaches to swine health programs continue to evolve. This paper presents some concepts in swine health that are currently important and that likely will increase in importance in the future.

Concept No. 1. Swine health programs need to be based on accurate information. The approach to herd health and productivity problems is becoming much more quantitative and objective. The integration of economic and biologic data will become a major component of swine herd health programs. Leading veterinary practices are those that supply new information to their clientele. They become involved with producer groups and facilitate exchange of information and the continuing education of their clients. In return, they need accurate information from thier clients upon which to base decisions. Successful swine health programs involve the veterinary practitioner in the decision-making process.

Concept No. 2. Successful swine health programs have a major emphasis on diagnostics. Producers with large investments have a justifiably high "need-to-know" level. Clinical and laboratory efforts to confirm the presence and level of pathogenic substances and organisms are necessary before implementation of costly treatment, and in some cases, prevention programs. Efforts to determine the cost of the presence of organisms versus the cost of treatment and prevention are necessary. Diagnostic efforts to "rule-out" certain major pathogens, rather than confirming the presence of every potential pathogen, are becoming more important. Surveillance programs to monitor changes in health status are becoming a part of swine health programs. These types of programs include periodic slaughter checks, routine post-mortem examinations, and serological profiles. Diagnostic efforts are expanding, via better information, to include production system failures, or what has been termed "lesionless pathology".

Concept No. 3. New programs in swine health will be primarily management-oriented, not product-oriented. The strategic use of biologic and pharmaceutical agents based on accurate information and documented need will remain useful and necessary, but will be subjected to much more critical evaluation for cost-effectiveness and return on investment. More emphasis will be placed on management practices that promote herd health and that act as disease control measures. Some of these types of practices include two or three site production systems, increased farm biosecurity, maintenance practices that promote herd health and that act as disease control measures. Some of these types of practices include two or three site production systems, increased farm biosecurity, maintenance of pig group integrity and use of all-out production systems throughout the finishing period, maintenance of proper animal stocking densities and adequate ventilation systems, and maximum use of heterosis.

PNEUMONIA ASSOCIATED WITH SALMONELLA CHOLERAE-SUIS INFECTION IN MISSOURI SWINE: 85 Cases (1987-1990)

James R. Turk, DVM, PhD; William. H. Fales, PhD;
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Lanny W. Pace, DVM, PhD; John R. Fischer, DVM;
John M. Kreeger, DVM, PhD; Gayle C. Johnson DVM, PhD;
Susan E. Turnquist, DVM, MS; H. S. Gosser, DVM, PhD

SUMMARY

Salmonella cholerae-suis was identified in pure or mixed bacterial cultures from 134 accessions of swine necropsied from January 1, 1987, through June 30, 1990. Pneumonia was present in 85 of 94 accessions from which this bacterium was identified in the absence of other significant bacteria. Pneumonia occurred more frequently than hepatitis, splenomegaly, or colitis. Pleuropneumonia that was grossly indistinguishable from that associated with Actinobacillus pleuropneumoniae occurred in 26 of 85 accessions from which Salmonella cholerae-suis was the only bacterium identified.

INTRODUCTION

Salmonella cholerae-suis may produce enterocolitis and septicemia with cutaneous cyanosis, splenomegaly, and hepatitis in swine. Pneumonia is usually considered to be a minor component of salmonellosis, however, bronchopneumonia resembling pneumonic pasteurellosis and pleuropneumonia resembling that associated with Actinobacillus pleuropneumoniae have been described. Identification rates of salmonella from swine with pneumonia have increased in Missouri in recent years. The purpose of this retrospective study was to examine the relative incidence of pneumonia, pleuritis, colitis, splenomegaly, and hepatitis in swine from which Salmonella cholerae-suis had been identified.

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The authors acknowledge the support of the Missouri Department of Agriculture, the Missouri Pork Producer's Association, and the diagnostic efforts of Drs. Tom Brown, and Dan Shaw.

MATERIALS AND METHODS

Swine necropsied at the Veterinary Medical Diagnostic Laboratory, University of Missouri, from January 1, 1987, through June 30, 1990, were examined for gross evidence of pneumonia, pleuritis, splenomegaly, and colitis. Lung was cultured bacteriologically for Pasteurella multocida, Actinobacillus pleuropneumoniae, Salmonella cholerae-suis and other bacteria. Colon, spleen, and/or liver were cultured for Salmonella cholerae-suis and other bacteria in accessions with lesions or clinical histories suggestive of septicemia. Lung and/or tracheal swabs were cultured for Mycoplasma hyopneumoniae in accessions with gross lesions suggestive of mycoplasmosis.

Routine tissues were collected in neutral phosphate-buffered, 10% formalin and processed for histologic examination. Lung was examined histologically for lesions characteristic of Mycoplasma hyopneumoniae. When available, liver was examined histologically for the presence of necrotizing hepatitis and paratyphoid nodules.

RESULTS

Salmonella cholerae-suis was identified in pure or mixed bacterial cultures with Pasteurella multocida or Actinobacillus pleuropneumoniae in 134 (7.6%) of 1754 accessions of swine (Tables 1&2). Salmonella cholerae-suis was identified in a greater percentage of necropsy accessions in 1988 (8.0%), 1989 (7.5%), and 1990 (10.4%) than in 1987 (5.7%) (Table 1).

Salmonella cholerae-suis was the only significant bacterium identified in 94 accessions (Table 2). Pneumonia occurred in 85 (90.4%) of these accessions and was present more often than hepatitis, splenomegaly, or colitis (Table 2). The pneumonia varied from focal bronchopneumonia to multifocal hemorrhagic pneumonia. Fibrinous pneumonia and pleuritis occurred in 26 (27.7%) accessions from which Salmonella cholerae-suis was identified in pure culture.

Pneumonia occurred in all 40 accessions in which Salmonella cholerae-suis was identified in mixture with Pasteurella multocida (33), Actinobacillus pleuropneumoniae (5), or both of these bacteria (2) (Table 2). Pleuritis occurred in 11 of 33 mixed infections with Pasteurella multocida, and in 7 of 7 mixed infections with Actinobacillus pleuropneumoniae (Table 2).

Grossly evident lobular consolidation and collapse, and histologic cuffing of airways and pulmonary vessels by mononuclear leukocytes consistent with mycoplasmosis were present in 13 accessions in which Salmonella cholerae-suis was the only bacterium identified, and in 11 from which it was identified in mixture with Pasteurella multocida, and/or Actinobacillus pleuropneumoniae. Cultures for Mycoplasma spp. were positive in 1 and 2 accessions with pure or mixed bacterial cultures of Salmonella cholerae-suis, respectively.

DISCUSSION

The identification of Salmonella cholerae-suis and Actinobacillus pleuropneumoniae requires special bacteriologic media and techniques. Actinobacillus pleuropneumoniae has been isolated by dilution techniques from outbreaks of pneumonia in which Pasteurella multocida was the only initial isolate using conventional techniques. We identified mixed bacterial infections of Salmonella cholerae-suis, Pasteurella multocida and/or Actinobacillus pleuropneumoniae in 40 accessions indicating that our bacteriologic techniques are capable of detecting mixed infections with these bacteria. The possibility remains, however, that Pasteurella multocida or Actinobacillus pleuropneumoniae may have been present in some accessions of pneumonia from which Salmonella cholerae-suis was the only bacterium identified. This is especially true for those swine which were on medicated feed or which had received antibiotic therapy since there are differences in the antimicrobial susceptibility patterns of these bacteria.

Salmonella cholerae-suis was identified in a greater percentage of accessions during the first 6 months of 1990 than for the years of 1987, 1988, and 1989. This does not appear to have been due only to seasonal influences and may reflect an increase in the incidence of the disease, more attempts at bacteriologic culture, greater success of those attempts, or a mixture of these factors.

Mycoplasma spp. were isolated from 1 accession from which Salmonella cholerae-suis was identified in pure culture and 2 with mixed culture. It is probable that other accessions of pneumonia in which there was pure or mixed bacterial growth also were infected with Mycoplasma spp. that could not be identified by culture.

Septicemia or enterocolitis have been reported as the typical manifestations of salmonellosis in swine. In this retrospective study, pneumonia occurred more frequently than hepatitis, splenomegaly or colitis, and was the most common lesion associated with Salmonella cholerae-suis infection. It has been demonstrated that pneumonia can be produced by intranasal instillation of Salmonella cholerae-suis, while oral exposure results in enterocolitis and septicemia. We conclude that aerosol exposure to Salmonella cholerae-suis may be responsible for many accessions with pneumonia in the absence of enterocolitis or septicemia and recommend that bacteriologic culture for this bacterium be performed routinely on swine with pneumonia.

Table 1. Salmonella cholerae-suis identification in swine necropsied from January 1, 1987, through June 30, 1990.

	Salmonella cholerae-suis	Total accessions	Percent
1987	27 (19)*	471 (237)	5.7 (8.0)
1988	40 (20)	501 (259)	8.0 (7.7)
1989	37 (15)	493 (281)	7.5 (5.3)
1990	(30)	(289)	(10.4)
Total#	134	1754	7.6

* = (January through June)
\# = total January 1, 1987, through June 31, 1990

Table 2. Lesions observed in swine from which Salmonella cholerae-suis was identified, January 1, 1987, through June 30, 1990.

	Total	Pneu-monia	Hepatitis/ examined	Pleur-itis	Spleno-megaly	Colitis
Sc*	94	85	55/63	26	50	25
Sc+Pm#	33	33	16/21	11	14	11
Sc+Ap**	5	5	1/3	5	2	2
Sc+Pm+Ap	2	2	0/2	2	1	0
Total	134	125	72/89	44	67	38

* Sc = Salmonella cholerae-suis
\# Pm = Pasteurella multocida
** Ap = Actinobacillus pleuropneumoniae

PLEUROPNEUMONIA IN MISSOURI SWINE: 53 cases (1989-1990)

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Lanny W. Pace, DVM, PhD; John R. Fischer, DVM;
Gayle C. Johnson, DVM, PhD; Susan E. Turnquist, DVM, PhD;
John M. Kreeger, DVM, PhD; Harvey S. Gosser, DVM, PhD

SUMMARY

From January 1, 1989, through June 30, 1990, the University of Missouri, Veterinary Medical Diagnostic Laboratory received 53 accessions of necrotizing, hemorrhagic, fibrinous pleuropneumonia in swine. Pasteurella multocida type D was identified in pure culture from lungs in 14 of 53 accessions with pleuropneumonia. Pure cultures of Actinobacillus pleuropneumoniae or Salmonella cholerae-suis were identified from pleuropneumonic lung in 13 and 7 accessions, respectively. Mixed infections with Pasteurella multocida, Salmonella cholerae-suis, and/or Actinobacillus pleuropneumoniae were identified from lung in 11 accessions, and no significant bacterial growth in 6 accessions with pleuropneumonia. Pasteurella multocida type A was isolated in pure culture from 2 accessions with pleuropneumonia. The gross lesions of cutaneous hyperemia, splenomegaly, multifocal hemorrhagic lymphadenopathy or colitis were not helpful in differentiating accessions from which these three bacteria were identified. On histologic examination, multifocal necrotizing hepatitis was present only in accessions from which Salmonella cholerae-suis was isolated.

INTRODUCTION

Pasteurella multocida is an important bacterium associated with pneumonia in swine. Suppurative bronchopneumonia in the absence of pleuritis is the typical lesion associated with porcine pneumonic pasteurellosis, but fibrinonecrotic pneumonia with pleuritis may be observed. Epidemiologic studies indicate that most outbreaks of acute fibrinonecrotic pleuropneumonia in swine are associated with Actinobacillus pleuropneumoniae. In individual outbreaks there may be no pathologic features which differentiate pleuropneumonia associated with Pasteurella multocida and Actinobacillus pleuropneumoniae.

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Salmonella cholerae-suis may produce subtle pulmonary lesions varying from focal to diffuse consolidation to more severe fibrinonecrotic pneumonia similar to that associated with Actinobacillus pleuropneumoniae or Pasteurella multocida. Extrathoracic lesions of cutaneous hyperemia, splenomegaly, multifocal lymphadenopathy, colitis, or hepatitis may be helpful in differentiating pneumonia associated with salmonellosis from that associated with Pasteurella multocida or Actinobacillus pleuropneumoniae. The purpose of this study was to examine the incidence of Pasteurella multocida, Actinobacillus pleuropneumoniae, and Salmonella cholerae-suis in necrotizing, hemorrhagic, fibrinous pleuropneumonia in Missouri swine, and to identify lesions which might aid in differentiating these agents at necropsy.

MATERIALS AND METHODS

Case material was derived from swine necropsied at the Veterinary Medical Diagnostic Laboratory, University of Missouri, from January 1, 1989, through June 30, 1990. Accessions with pneumonia were examined for the presence of concomitant pleuritis, cutaneous hyperemia, splenomegaly, lymphadenopathy, and colitis at necropsy. Tissues were collected in neutral phosphate-buffered, 10% formalin and processed routinely for histologic examination. Lung was examined histologically for histologic lesions characteristic of Mycoplasma spp. When available, liver was examined histologically for the presence of necrotizing hepatitis.

Lung was cultured for Pasteurella multocida, Actinobacillus pleuropneumoniae, Salmonella cholerae-suis and other bacteria. Culture for Mycoplasma spp. was performed in cases with typical gross lesions.

RESULTS

Two hundred seventy-one (271) of 782 swine accessions necropsied had pneumonia. Pasteurellae were isolated in pure or mixed culture in 89 accessions. Pasteurella multocida type D was identified in 68, Pasteurella multocida type A in 13, and Pasteurella spp. in 7 accessions. Salmonella cholerae-suis was isolated in pure or mixed culture from lung in 60, and Actinobacillus pleuropneumoniae in 23 accessions. There were 19 mixed infections with pasteurellae and Salmonella cholerae-suis, 7 with Pasteurella multocida type D and Actinobacillus pleuropneumoniae, and 2 with all 3 bacteria.

Gross and histologic lesions suggestive of infection with Mycoplasma spp. were seen in 71 accessions. Cultures for Mycoplasma spp. were often overgrown by secondary bacteria precluding definitive diagnosis. Mycoplasma spp. were identified by culture in 6 accessions, 1 in which Pasteurella multocida type D was identified in pure bacterial culture, 2 in which there were mixed infections with Pasteurella multocida type D and Salmonella cholerae-suis, and 3 in which there was no other significant bacterial growth.

Necrotizing, hemorrhagic, pleuropneumonia, with or without concomitant cutaneous hyperemia, splenomegaly, lymphadenopathy, or colitis was present in 53 accessions. Pure cultures of Pasteurella multocida, Actinobacillus pleuropneumoniae, or Salmonella cholerae-suis were identified in 36 accessions of pleuropneumonia (Table 1). There were mixed cultures of these bacteria in 11 accessions of pleuropneumonia (Table 2). Mycoplasma spp. was identified by culture in 1 of 13 accessions with mixed bacterial pleuropneumonia.

No significant bacterial growth was obtained from lungs in 6 accessions with pleuropneumonia.

Liver was examined histologically in 40 accessions with pleuropneumonia. Multifocal necrotizing hepatitis was present in 9 of 11 (82%) accessions from which Salmonella cholerae-suis was identified in pure or mixed bacterial culture. Hepatitis was not seen in any of the 29 accessions from which Salmonella cholerae-suis was not identified bacteriologically.

DISCUSSION

It is difficult to produce pneumonia experimentally using pure inocula of many Pasteurella multocida strains, however, the MSU 7 strain has been reported to produce pneumonia reliably. The potential role of Pasteurella multocida as a primary pulmonary pathogen in swine cannot be addressed in this retrospective study. Bacteria tend to be the final lethal insult in outbreaks of porcine pneumonia. For this reason prophylaxis and therapy often are directed toward the bacteria commonly identified in pneumonic swine. Pasteurella multocida type A has been identified more commonly than Pasteurella multocida type D in pig lungs in Minnesota and Ontario. In Missouri swine Pasteurella multocida type D was the most common bacterium identified in pneumonia and pleuropneumonia.

Pneumonic pasteurellosis in swine is generally considered to occur secondary to infections with parasites, viruses or Mycoplasma spp., and other stressors. Mycoplasma hyopneumoniae has been shown to exacerbate pulmonary infection with Actinobacillus pleuropneumoniae. Mycoplasma spp. were isolated from 5 accessions with pneumonia and 1 with pleuropneumonia in this study. It is probable that other accessions of pleuropneumonia in which there was pure, mixed, or no significant bacterial growth were secondary to Mycoplasma spp. infection that could not be identified by culture.

The identification of Actinobacillus pleuropneumoniae requires special bacteriologic media and techniques. Actinobacillus pleuropneumoniae has been isolated by dilution techniques from outbreaks of pneumonia in which Pasteurella multocida was the initial isolate using conventional techniques. We identified Actinobacillus pleuropneumoniae in 6 accessions from which there were mixed infections with Pasteurella multocida, 2 with Salmonella cholerae-suis, and 2 from which all 3 bacteria were identified indicating that our bacteriologic techniques are capable of detecting Actinobacillus pleuropneumoniae in mixed bacterial infections. The possibility remains, however, that Actinobacillus pleuropneumoniae or Salmonella cholerae-suis may have been present in some accessions of pleuropneumonia from which Pasteurella multocida was the only bacterium identified. This may be especially true of those swine which were on medicated feed or which had received antibiotic therapy since there are differences in the antimicrobial susceptibility patterns of these bacteria.

Splenomegaly, cutaneous hyperemia, and extrathoracic lymphadenopathy were observed in the majority of cases of pleuropneumonia from which Salmonella cholerae-suis was isolated in pure culture. These lesions were present in similar numbers of accessions in which Actinobacillus pleuropneumoniae or Pasteurella multocida type D were isolated in pure culture. Empirically, the presence or absence of these lesions was not helpful in differentiating pleuropneumonia associated with Pasteurella multocida, Actinobacillus pleuropneumoniae, or Salmonella cholerae-suis given the relative prevalence of these bacteria identified from pneumonic lungs of Missouri swine.

Colitis was present in 2 accessions of pleuropneumonia associated with Salmonella cholerae-suis, 1 as a pure culture and another as a mixed infection with Pasteurella multocida type D. Colitis was seen in 1 case of pleuropneumonia from which a pure culture of Pasteurella

multocida type D was obtained from the lung and in which Treponema hyodysenteriae was present in the colon. The presence or absence of colitis also was not helpful for differentiating the bacteria associated with pleuropneumonia at necropsy.

On histologic examination the most reliable indicator of the involvement of Salmonella cholerae-suis was multifocal necrotizing hepatitis. This lesion was not seen in any accessions of pure or mixed infections of Pasteurella multocida or Actinobacillus pleuropneumoniae.

In summary, Pasteurella multocida, Actinobacillus pleuropneumoniae, and Salmonella cholerae-suis were identified in pure or mixed cultures from pleuropneumonia in Missouri swine. There were no gross lesions which could reliably differentiate pleuropneumonia associated with these bacteria, however, Pasteurella multocida was the most common bacterium identified.

Table 1. Pure isolations of Pasteurella multocida, Salmonella cholerae-suis, or Actinobacillus pleuropneumoniae from porcine pleuropneumonia and associated extrathoracic lesions, January 1, 1989 through June 30, 1990.

	Total	Cutaneous hyperemia	Spleno-megaly	Extrathoracic lymphadenopathy	Colitis
PmD*	14	6	5	3	1
Apl#	13	6	5	3	0
Scs**	7	4	6	4	1
PmA##	2	1	1	1	0
Total	36	17	17	11	2

* PmD = Pasteurella multocida type D
\# Apl = Actinobacillus pleuropneumoniae
** Scs = Salmonella cholerae-suis
PmA = Pasteurella multocida type A

Table 2. Mixed isolations of Pasteurella multocida, Salmonella cholerae-suis, and Actinobacillus pleuropneumoniae from porcine pleuropneumonia and associated extrathoracic lesions, January 1, 1989 through June 30, 1990.

	Total	Cutaneous hyperemia	Spleno-megaly	Extrathoracic lymphadenopathy	Colitis
PmD*+Scs#	7**	3	5	7	1
PmD+Apl##	2	0	1	1	0
Psp***+Scs	1	0	1	1	0
PmD+Apl+Scs	1	0	0	1	0
Total	11	3	7	10	1

* PmD = Pasteurella multocida type D
\# Scs = Salmonella cholerae-suis
** Mycoplasma spp. also identified on culture in 1
Apl = Actinobacillus pleuropneumoniae
*** Psp = Pasteurella spp.

ATROPHIC RHINITIS IN MISSOURI SWINE: 300 Cases (1988-1990)

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SUMMARY

Atrophic rhinitis was identified by gross inspection of the nasal turbinates in 300 of 1283 swine necropsy accessions from January 1, 1988, through June 30, 1990. Pasteurella multocida was identified in pure culture from nasal swabs in 73 (24.3%), Bordetella bronchiseptica in pure culture in 35 (11.7%), and both of these bacteria in 66 (22.0%). There was no significant bacterial growth in 35 (11.7%), and culture was not attempted in 91 (30.3%). Accessions from which both Pasteurella multocida and Bordetella bronchiseptica were identified had significantly greater mean turbinate score than did those for either bacterium alone, and for those from which no significant bacterial growth was obtained. The mean turbinate score for accessions from which there were pure cultures of Pasteurella multocida were significantly greater than those from which either pure cultures of Bordetella bronchiseptica or no significant bacterial growth was obtained. There was significantly more pneumonia in swine with atrophic rhinitis than those without rhinitis for all etiologic categories except those in which there was no significant bacterial growth from nasal swabs. The mean turbinate scores for swine with pneumonia from which single or multiple etiologic agents were identified were significantly greater than those in which etiologic agents were not identified from pneumonic lesions. There was no difference in the turbinate scores of swine with atrophic rhinitis with pneumonia as compared to those with atrophic rhinitis and no pneumonia.

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INTRODUCTION

Atrophic rhinitis is considered by many to be a disease of uncertain cause. Recent experimental work indicates that either Bordetella bronchiseptica or Pasteurella multocida is capable of producing atrophic rhinitis. These bacteria may possess a variety of virulence factors that facilitate adherence, colonization, and damage to the porcine respiratory tract. Osteolytic or dermonecrotic toxin production by various strains of both Pasteurella multocida and Bordetella bronchiseptica has been identified. The term progressive atrophic rhinitis has been suggested for those cases in which toxin producing strains of bacteria are identified. Vaccination with Pasteurella multocida toxin purified by monoclonal antibodies has been reported to protect swine from progressive atrophic rhinitis. The gene encoding this toxin has recently been cloned and may facilitate vaccine production.

Despite extensive experimental studies there have been few recent reports comparing the relative prevalence of Pasteurella multocida and Bordetella bronchiseptica in nasal swabs from field cases of atrophic rhinitis. Some studies have indicated that pneumonia occurred more frequently in pigs with atrophic rhinitis, while others have not. The purpose of this retrospective study was to determine the relative prevalence of Pasteurella multocida and Bordetella bronchiseptica in nasal swabs from swine with atrophic rhinitis and to determine the effect of atrophic rhinitis on the prevalence of pneumonia in swine presented for post mortem examination to the University of Missouri Veterinary Medical Diagnostic Laboratory.

MATERIALS AND METHODS

Swine necropsied at the Veterinary Medical Diagnostic Laboratory, University of Missouri, from January 1, 1987, through June 30, 1990, were examined for the presence of atrophic rhinitis. The snout was sectioned transversely at the level of upper premolar 1. Turbinates were scored at the time of necropsy, or retrospectively on the basis of descriptions of the turbinate scrolls and nasal morphology, as 0-5 for atrophic rhinitis. In the majority of accessions with atrophic rhinitis a single sterile swab was inserted into the most severely affected side of the turbinates caudal to the level of transection. Swabs were cultured bacteriologically for Pasteurella multocida, Bordetella bronchiseptica, and other bacteria. Nasal bacteriologic culture was not performed in swine in which there was no gross evidence of rhinitis. Examination for bacterial toxin production was not performed.

Accessions with atrophic rhinitis were grouped into the following categories based upon bacteriologic findings from nasal swabs: (1) pure Pasteurella multocida, (2) pure Bordetella bronchiseptica, (3) both bacteria, (4) no significant bacterial growth, and (5) no bacterial culture attempted.

Accessions with atrophic rhinitis also were grouped as those (6) with pneumonia, and (7) without pneumonia in which pneumonia had been identified by gross and histologic examination, and by bacteriologic culture for Pasteurella multocida, Bordetella bronchiseptica, Actinobacillus pleuropneumoniae, Salmonella cholerae-suis and other bacteria. Mycoplasma spp infection was assessed by culture of lung or tracheal swabs, or was inferred by the presence of typical hyperplasia of bronchiolar mucosa and peribronchiolar cuffing by lymphocytes and macrophages on histologic examination of lung. Group 8 consisted of swine with pneumonia in which atrophic rhinitis had not been detected. Group 9 consisted of swine with no atrophic rhinitis or pneumonia. No attempt was made to retrospectively grade pneumonic lesions. The age of

affected animals was recorded when available.

The Student's T test was performed to detect differences in the turbinate grades and ages of various groups. The Chi-square test was performed to detect differences in the presence or absence of pneumonia.

RESULTS

Atrophic rhinitis was identified by gross inspection of the nasal turbinates in 300 (23.2%) of 1283 swine accessions. The bacteriologic findings from nasal swabs, turbinate scores and age for Groups 1-5 are listed in Table 1. Pasteurella multocida was identified in pure culture from nasal swabs in 73 (24.3%, Group 1), Bordetella bronchiseptica in pure culture in 35 (11.7%, Group 2), and both Pasteurella multocida and Bordetella bronchiseptica in 66 (22.0%, Group 3) of 300 accessions. There was no significant bacterial growth in 35 (11.7%, Group 4) and bacteriologic culture was not attempted in 91 (30.3%, Group 5) accessions. The mean turbinate score for swine in Group 3 (both bacteria identified) was significantly greater than those for Groups 1, 2, 4 and 5. The mean turbinate score for swine in Group 1 (pure cultures of Pasteurella multocida) was significantly greater than those for Groups 2 and 5. There were no statistically significant differences in the ages of swine from any Group.

Pneumonia was present in 235 (78.3% of Group 6) of swine accessions with atrophic rhinitis (Table 2). There was no evidence of pneumonia in 59 (Group 7) accessions with atrophic rhinitis. Pneumonia was present in only 89 (Group 8) accessions in which there was no evidence of atrophic rhinitis. There was no evidence of atrophic rhinitis or pneumonia in 778 (Group 9) accessions. There were a total of 906 accessions without evidence of pneumonia, however, examination for atrophic rhinitis was not recorded in 122 which were deleted from the study. There were no positive or negative findings listed for the lung in an additional 6 accessions which were deleted from the study.

The etiologic agents identified from pneumonic lung, the mean turbinate scores and ages of the 235 Group 6 accessions with atrophic rhinitis are listed in Table 3. Pasteurella multocida was identified by bacteriologic culture in 83 (27.7%), Salmonella cholerae-suis in 67 (21.3%), Streptococcus spp. in 48 (16%), Actinobacillus pleuropneumoniae in 20 (6.7%), Actinomyces pyogenes in 14 (4.7%), and Bordetella bronchiseptica in 6 (2%) of 235 accessions. Mycoplasma infection was identified in 83 (27.7%) accessions, 9 by culture, and 74 by inference from gross and histologic lesions. All other categories of pneumonia by etiologic agent had greater mean turbinate scores than did those from which Bordetella bronchiseptica was identified in lung. Single etiologic agents were identified from pneumonic lung in the 108 (45.9%), multiple etiologic agents in 105 (44.7%), and no etiologic agent in 22 (9.4%) of 235 accessions with atrophic rhinitis (Table 4). Accessions with multiple or single etiologic agents had significantly greater mean turbinate scores than did those for which no agent was identified in pneumonic lung.

There were no significant differences in the ages of swine with atrophic rhinitis and pneumonia from which a variety of etiologic agents were identified.

DISCUSSION

A variety of factors including genetics, dietary calcium levels, atmospheric ammonia levels, and infection with Haemophilus parasuis have been implicated as predisposing to atrophic rhinitis. Bordetella bronchiseptica was once thought to be the major cause of atrophic rhinitis in swine. Recent experimental work indicates that Pasteurella multocida or Bordetella bronchiseptica is capable of producing turbinate atrophy in swine. Reversible atrophic rhinitis has been produced experimentally by intranasal inoculation of Bordetella bronchiseptica, whereas, intranasal inoculation of Pasteurella multocida resulted in progressive atrophic rhinitis. Concurrent inoculation with both bacteria has resulted in more severe atrophic rhinitis.

A recent study of selected Illinois swine herds indicated that there was no correlation between bacteriologic findings and atrophic rhinitis. The nares of swine with and without atrophic rhinitis were cultured bacteriologically in that study of preselected herds in which a variety of vaccines and antibiotics had been used. Assay of the toxin producing capabilities of bacteria identified from nasal swabs was not performed in the above mentioned study or in this retrospective study. The contradictory observations regarding bacterial association with atrophic rhinitis may reflect differences in the bacteriologic materials and methods, and in the swine populations selected for these studies, and could possibly be resolved by data concerning toxin production of the bacteria identified.

There are few reports concerning the relative incidence of Pasteurella multocida and Bordetella bronchiseptica in naturally occurring atrophic rhinitis in the general swine population. In this retrospective study the greatest mean turbinate scores occurred in pigs from which both organisms were identified. This observation concurs with previous reports that more severe disease results from dual infection with these bacteria. Pasteurella multocida was identified more commonly in this study and was associated with significantly greater mean turbinate scores than was Bordetella bronchiseptica from the general swine population submitted for post mortem examination. This observation conflicts with previous reports that Bordetella bronchiseptica was most commonly isolated from nasal swabs of Iowa swine.

Some studies have indicated that pneumonia occurred more frequently in pigs with atrophic rhinitis, while others have not. In this retrospective study there was significantly more pneumonia in swine with atrophic rhinitis than those without atrophic rhinitis. Pasteurella multocida was the most common agent identified in pneumonic lungs. There were no differences in the mean turbinate scores of swine with or without pneumonia. The mean turbinate scores for swine with pneumonia from which etiologic agents were identified were significantly greater than those with pneumonia from which no agent was identified, however. The pneumonia in these latter accessions may have been inactive or undergoing resolution in association with low-grade or regressing lesions of atrophic rhinitis.

In summary, Pasteurella multocida was more prevalent than was Bordetella bronchiseptica in nasal swabs from Missouri swine with atrophic rhinitis. Mean turbinate scores were greatest for those in which both agents occurred and were more severe in those with pure Pasteurella multocida than those with pure Bordetella bronchiseptica. Pneumonia occurred more frequently in swine with atrophic rhinitis than those without atrophic rhinitis. We conclude that bacteriologic examination of nasal swabs from swine with atrophic rhinitis is a prerequisite for the development of specific prophylactic/therapeutic recommendations for pork producers attempting to control this common disease.

Table 1. Bacteriologic findings from nasal swabs of swine with atrophic rhinitis, January 1, 1988, through June 30, 1990.

Group	Total	Mean Turbinate score (S.D.)	Mean Age* days (S.D.)
1. Pasteurella multocida	73	2.6# (1.2)	133.1 (160.5)
2. Bordetella bronchiseptica	35	2.1 (1.1)	90.5 (40.7)
3. Both bacteria	66	2.9# (0.9)	95.5 (35.0)
4. No significant growth	35	2.4 (1.0)	107.4 (81.3)
5. No culture	91	2.2 (1.2)	127.1 (138.7)
TOTAL	300	2.5 (1.1)	115.7 (117.6)

* No significant differences in ages between Groups 1-5.

\# significantly greater in Group 1 than Groups 2&5;
Group 3 greater than Groups 1,2,4,&5 at $P<0.05$ or less.

Table 2. Prevalence of pneumonia by etiologic category of atrophic rhinitis, January 1, 1988, through June 30, 1990.

Group	Pneumonia	No pneumonia
1. Pasteurella multocida	58	15
2. Bordetella bronchiseptica	28	7
3. Both bacteria	56	10
4. No significant growth	23	12
5. No culture	78	13
6&7. All atrophic rhinitis	235	59[#]
8&9. No atrophic rhinitis	89	778[**]

* Groups 1,2,3,&5 had significantly at $P<0.005$ when compared with Groups 8&9 by the Chi-square test.

\# 6 accessions deleted which contained no description of positive or negative findings for lung.

** accessions without turbinate exam (122) deleted.

Table 3. Agents identified from lungs of swine with atrophic rhinitis (Text Group 6), January 1, 1988, through June 30, 1990.

Agent	Total	Mean Turbinate score (S.D.)*	Mean Age in days (S.D.)
Pasteurella multocida	83	2.8 (1.1)	107.2 (48.1)
Salmonella cholerae-suis	67	2.4 (1.1)	90.2 (30.7)
Streptococcus spp.	48	2.8 (1.2)	128.3 (125.5)
Actinobacillus pleuropneumonia	20	2.8 (1.1)	97.0 (37.8)
Actinomyces pyogenes	14	2.4 (0.9)	69.7 (22.6)
Bordetella bronchiseptica	6	1.2 (0.4)	49.0 (1 only)
Mycoplasma spp#	83	2.6 (1.2)	96.1 (39.1)

* all other categories of pneumonia had greater ($P<0.05$ or less) mean turbinate scores than those with Bordetella bronchiseptica.

\# Mycoplasma spp, 9 by culture, 74 by gross and histologic lesions

Table 4. Number of agents identified from lungs of swine with atrophic rhinitis and pneumonia (Text Group 6), January 1, 1988, through June 30, 1990.

	Total	Mean Turbinate score (S.D.)*	Mean Age in days (S.D.)
Single	108	2.6 (1.2)	103.3 (89.5)
Multiple	105	2.6 (1.1)	99.4 (38.9)
None	22	2.0 (1.0)	107.7 (59.6)

* = mean turbinate scores for accessions with pneumonia from which single or multiple agents were identified were significantly greater ($P<0.05$) than that for pneumonia in which no agents were identified.

COMPOSTING DEAD SWINE ON THE FARM[a]

Trygve L. Veum, Jeffre D. Firman, Charles D. Fulhage,
Ronald L. Plain and Robert B. Miller

The objectives were:

(1) To develop a nonpolluting composting method for the sanitary disposal of dead swine at the University of Missouri Swine Farm, and

(2) To demonstrate the practical effectiveness of composting as a means of reducing the biological contamination of surface and ground water.

Justification

About five million swine are produced in Missouri annually (MO Farm Facts, 1989). Death losses from birth to weaning average 20 to 25% (Gastonbury, 1977), with another 4 to 6% from weaning to market (Plain, 1989). Thus, these death losses represent about 1.2 to 1.7 million pigs from birth to weaning, with another .2 to .3 million from weaning to market, respectively. Most of these dead pigs are buried in the ground on the farm. An obvious result is contamination of the ground water and/or pollution of Missouri streams. Diseases may also be spread by wild animals and dogs feeding on the carcasses not appropriately buried.

While burning of the carcasses is a sanitary means of disposal, the energy cost is high and the exhaust may contribute to acid rain, further compromising water quality in our streams and lakes. Thus it appears prudent to explore an environmentally sound approach to dispose of dead swine on the farm. We propose to develop a compost method, similar to a method developed for the composting of dead broilers and laying hens (Murphy, 1989a, b). Willson et al. (1980) have described the biological process of composting sewage sludge by the aerates pile method.

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Marvin D. Hoffman and Jamey R. Cline are thanked for operating the composting unit and collecting the data.

Why choose composting?

1. It is a natural, biologically sound process.

2. Properly done, composting generates internal temperatures of about 150°F which destroys pathogenic bacteria and viruses.

3. Composting produces a useful, inoffensive product, which may be applied on the land.

4. Composting is a relatively simple, cheap and effective means of degrading biological material.

Experimental Approach

Compost Facility:

Initially, consideration was given to constructing a compost shed similar to that designed for composting poultry (Murphy, 1989 a,b). Alternatively a more modest approach was chosen. Two pens on the end of an old open front swine building at UMC were utilized for this composting project. Each 9.5 x 24 foot pen has a solid concrete floor, with the rear 9.5 ft under roof. The rear wall and pen partitions are solid concrete to a height of 4 feet.

Two compost bins, 3.2 x 9.5 ft, were constructed under roof in each pig pen. Removable dividers were made by using treated (CCA) boards (2" x 6") stacked vertically. The bins are covered with a wire mesh gate until completely filled to prevent access by animals, (particularly dogs) which may scatter debris. The roof is essential to keep rain off the bins. Excess moisture will prevent air from entering the bin.

Composting Procedure:

Dead pigs are being composted using a procedure similar to that described by Murphy (1989b) and Willson (1989). Important requirements include:

(1) Carbon/Nitrogen ratio of 15 to 40.

(2) Moisture content of 40 to 60%.

(3) A pH of 5 to 12.

(4) At least 30% free air space.

The recipe used during the fall of 1990 was as follows:
Layer 1. The concrete floor must have a good layer of dry straw. This is essential to absorb moisture and allow Layer 1:

(continued)

Layer 1: sufficient air (oxygen) into the bottom of the bin. About 150 pounds (three bales) of straw was added, which was about 5 pounds per sq. foot of floor space. This appears adequate for farrowing and nursery pigs. However, if finisher pigs or sows are added first the amount of straw should be increased accordingly, possibly by 100 to 200 pounds.

Layer 2: Addition of dead pigs. This was done once daily when material was available. Leave at least 6 in. around the perimeter for air circulation. Spread out in a flat layer.

Layer 3: Dry manure - straw mixture. Use an amount equal to the weight of the pigs added.

Layer 4: Straw equal to one half the weight of the pigs added.

This was repeated, starting with layer 2, until the bin was full. Composting will occur while the bin is being filled, which will enable the operation to continue adding material until the bin is full.

Progress Report

Two bins have been filled. The first bin filled has been manually transferred and relayered (inverse to original) in an adjacent bin. Most small pigs were composting satisfactorily. One sow was not composting well, which appeared to be the result of insufficient straw added.

Our preliminary results suggest that the manure-straw mixture should be fairly dry. The straw must be dry.

In comparison to the poultry composting formula, it appears that more attention must be given to avoiding the use of wet, sloppy manure or a wet manure-straw mixture when composting swine. This results from the fact that poultry excreta is generally dryer than swine waste, dependent upon the amount of bedding (straw, etc.) used (if any). Thus, if a relatively dry manure mixture is not available, it may be necessary to use less manure and more dry straw, especially when composting market hogs and sows.

References

Gastonbury, J. R. W. 1977. Preweaning mortality in the pig. The prevalence of various causes of preweaning mortality and the importance of some contributory factors. Australian Vet. J. 53:315.

Missouri Farm Facts. 1989. MO. Agric. Statistics Office. P. O. Box L, Columbia, MO 65205.

Murphy, D. W. 1989a. Composting of dead birds. Dept. Poultry Sci., University of Maryland, Princess Anne, MD 21853.

Murphy, D. W. 1989b. Step-by-step composting. Dept. Poultry Sci., University of Maryland, Princess Anne, MD 21853.

Plain, Ron. 1989. 1988 Missouri Hog Returns. Farm Management Newsletter, FM 89-1, UMC, Dept. Agric. Economics, Columbia, MO 65211.

Willson, G. B. 1989. Combining raw materials for composting. Biocycle. August. pp. 82-85.

Willson, G. B., J. F. Parr, E. Epstein, P. B. Marsh, R. L. Chaney, D. Colacicco, W. D. Bunge, L. J. Sikora, C. F. Tester, S. Hornick. 1980. Manual for composting sewage sludge by the Beltsville aerated pile method. Municipal Environmental Research Laboratory. Office of Research and Development. U. S. Environmental Protection Agency. Cincinnati, Ohio 45268. pp. 65.

NON-SURGICAL EMBRYO TRANSFER IN SWINE

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SUMMARY

Surgically collected embryos were transferred to 32 crossbred gilts with a sterile inseminating spirette. Twenty-one of the transfers met the laboratory's criteria for good transfers. Of these 21 transfers, eleven (52%) resulted in pregnancies. Two pregnant gilts aborted, and nine litters averaging 4.3 pigs each were born. This litter size represents a 39% survival rate for embryos transferred to the recipients. Ninety-five percent of pigs were born live with an average birth weight of 3.7 pounds. Although pregnancy rate and embryo survival rate were lower than practical, this work provides the basis for perfection of the technique to useful levels.

INTRODUCTION

Embryo transfer in pigs has been possible since the early 1960's and has become very useful as an experimental tool. However, embryo transfer has not made the transition from research to practical application in swine. Embryo transfer in pigs does not have the clear economic advantage of tremendously increasing the numbers of offspring of superior females that it does in cattle. Nevertheless, it has a place in the swine industry as a means of introducing new animals into closed herds, establishing SPF herds, and preserving bloodlines of herds stricken with disease. When the problems of freezing pig embryos are solved, embryo transfer can facilitate international transport of genetic material as well. A non-surgical method of transfer could reduce the cost and difficulty of embryo transfer in swine significantly. The research described below was designed to develop a simple, non-surgical method of transfer of surgically collected pig embryos.

METHODS

Seventy-one crossbred gilts were used to develop a method for non-surgical embryo transfer in swine. Thirty-nine gilts which had exhibited at least one normal estrous cycle (18 to 23 d) were used as donors for 32 gilts which had exhibited estrus at least once. Estrous detection was done once daily. On day 3 to 5 of an estrous cycle donors were anesthetized with 1 g sodium thiopental and maintained on a surgical plane of anesthesia with an oxygen:halothane mixture. One ovary and 50 cm of one uterine horn were exteriorized through a midventral incision. Ovulation rate was recorded and perforated tygon tubing was inserted through an incision in the oviduct into the uterus near the tubo-uterine junction. Embryos were flushed from each uterine horn with 30 ml sterile Whitten's medium into a sterile, covered Petri dish.

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Embryos were examined under a microscope, washed once in Whitten's medium, and counted.

Recipients were not fed on the day of transfer and were mildly sedated 15 minutes before transfer. All recipients had exhibited estrus on the same day or a day later than the donor. Embryos were placed in a sterile tomcat catheter attached to a sterile 1 ml syringe and held in an incubator while the recipient was prepared.

The recipient was fed a small amount of grain and a sterile disposable inseminating spirette with a three-way stopcock attached to it was inserted into the cervix. When the spirette was firmly in place, the tomcat catheter containing the embryos was placed in the spirette and the embryos expelled into the sterile spirette. The tomcat catheter was withdrawn, the stopcock opened at right angles to the spirette, and 10-12 ml Whitten's medium was flushed through the spirette. Fifteen milliliters of atmospheric air were then used to force the medium out of the catheter. The spirette was withdrawn, observing for backflow of medium.

RESULTS AND DISCUSSION

Twelve of the 32 transfers resulted in pregnancies. Three of these gilts aborted between days 40 and 50 of pregnancy. Table 1. summarizes the results of the experiment. Good transfers were defined as those which met all of the following criteria:

1) The cervix of the recipient "locked down" on the spirette.
2) The medium and air flowed easily into the recipient's reproductive tract.
3) There was no backflow from the cervix at removal of the spirette.
4) The tip of the spirette was clean at removal.

Thus 52% of uneventful transfers resulted in pregnancies. A mean litter size of 4.3 (range of three to six) represented a forty-two percent embryo survival rate for good transfers. These are lower figures than expected for surgical transfers, but provide a basis for improvement to more practical pregnancy and embryo survival rates.

Table 2. illustrates the effect of synchrony of donors and recipients on success of the procedure. Because it was not the purpose of this work to compare these factors, the data presented here can only suggest that transfer within the range of days used in this study may be equally satisfactory.

The data presented in Table 3. suggest that at least in this laboratory, transfer is more successful with less advanced embryos.

CONCLUSION

Non-surgical embryo transfer can result in pregnancy in 50% of uneventful transfers, with an 82% farrowing rate and a mean litter size of 4.3 pigs when 10 - 12 embryos are transferred to recipients. These results provide a basis for further work to improve pregnancy rates and litter size to practical levels.

Table 1. Summary of results including success rates for good and bad transfers.

	Total	Embryos*	Pregnancies(%)	Litters Born(%)	Pigs Born Live*
Good Transfers	21	10.2 ± .6	11 (52)	9 (82)	4.0 ± .4
Bad Transfers	11	12.5 + 1.5	1 (9)	0 (0)	0
Total	32	11.0 + .7	12 (38)	9 (28)	4.0 + .

* Mean ± SEM

Table 2. Effect of synchrony of donors and recipients on success of transfers.

Treatment	Transfers	Pregnancies	Litters
Day 3 to 3	3 (2)	1	0
Day 4 to 4	30 (7)	10	9
Day 5 to 4	3 (1)	1	0
Day 5 to 5	1	0	0

Table 3. Effect of stage of embryos on success of transfers.

Embryos	Transfers	Pregnancies	Litters
Blastocysts	3 (2)	0	0
Morulae	13 (3)	5	4
8-cell/morulae	7 (2)	4	3
8-cell	2 (1)	1	1
4-8 cell	4 (2)	2	1
4 cell	3 (1)	0	0