Soy Swine
Nutrition Research Program

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Program Activities

The first year of the Soy/Swine Nutrition program saw a lot of behind-the-scene activity. At the National Soybean Research Laboratory at the University of Illinois, we've worked to improve the processes that keep the program responsive to the needs of our investigators, sponsors and stakeholders. Steve Sonka and Bob Easter work together to coordinate the program, and Marilyn Nash manages many of the daily program activities. You can check out periodic updates on Soy/Swine meetings and, eventually, preliminary research results from year 1 projects at our Web site: www.nsrl.uiuc.edu/swine.html.

Many thanks go to our investigators who responded to the request for research progress reports last winter. We will soon develop final report guidelines for investigators to use as they finish their year 1 work. Some may hear from Marilyn this summer as she reconciles project and program budgets.

Team leaders coordinating research projects under the program objectives had input from industry representatives as they helped generate the plan of work document out-lining desired research needs and directions for next year's program. The Illinois Soybean Program Operating Board is considering this plan for future funding.

Highlights of Research Results

Year 1 projects are at various stages of completion. While some began last fall, others depended upon the completion of soybean and meal sampling and analyses before feeding trials began this spring. Some of our participating scientists had available news and preliminary results.

Objective 1

Soybean meal has high acceptability, and is considered one of the better and cheaper protein sources for swine, but it still has nutritional limitations. A team of U.S. and international scientists led by Don Mahan (Ohio State University) is investigating how anti-nutritional factors affect amino acid quality. Their specific research areas and questions they expect to answer through this work are:

- Different processing methods affect variability of products used by feed manufacturers—how much do they vary?
- Phosphorus bound in soy protein phytate has a low bioavailability once phytase is added to release the phosphorus—will it also allow more of the amino acids to be utilized?
- Heat is applied to soybean meal—what are the effects of higher or lower temperatures on amino acid availability among various ages of swine?
- Particle size of soybeans averages around 850 microns—will a smaller particle size improve amino acid digestibility?
- High oil corns and other fats are used in swine diets—will dietary fat (or oil) affect the amino acid digestibility?
- Soy hulls are added to soybean meal as filler and fiber source—will amino acid digestibility be affected?

The ultimate goal is to make soybean meal almost completely digestible by swine thus reducing or eliminating the nutrient excesses that may cause a potential problem to the environment.

Technician Kristen Brennan, University of Illinois, weighs soybean samples from spring crop for analyses of ureases.

Objective 2

Year 1 goals of the carbohydrate nutrition work are to 1) characterize the soybeans' nutrient profiles obtained from the U.S., China, Brazil and India and 2) determine effects of processing on U.S. soybean meal composition and utilization. To address the first goal, George Fahey (University of Illinois) works with soybean samples collected from 5 Brazilian states, 6 Chinese provinces, 8 unspecified areas of India and 15 U.S. states. Nutrients being analyzed include: dry matter (DM), organic matter (OM), ash, crude protein (CP), KOH protein solubility, total lipid, total dietary fiber, and iron content.

Nutrient profiles will be compared between each state within a country and between countries. Laboratory analyses of all samples are ongoing, but some comparisons can be made now. For example: There are no differences in DM content but OM and CP differ between the U.S. states. Comparisons of Brazilian and U.S. soybeans show the U.S. beans have a greater DM content than Brazilian beans but Brazilian beans have a greater OM content. U.S. beans tend to have higher CP content and greater protein solubility.

The second goal involves collecting both whole soybeans and soybean meal from 10 U.S. processing plants. The plants utilized were chosen to maximize diversity in geographical location and processing procedures. Although all samples are not collected, laboratory analysis is progressing on samples we have to date.

Objective 3

Naturally occurring bioactive estrogenic compounds present in soybean meal have varying effects on reproduction and growth. Todd Winters (Southern Illinois University) investigates how soy phytoestrogens affect the endocrinology of the swine estrous cycle and ovulatory capacity of the porcine ovary. Ovarian cell cultures were treated with phytoestrogens genistein, daidzen, and the gilts' natural estrogen, estradiol-17.

Early results show genistien and daidzen decrease follicular cell atresia in cell culture, with daidzein about 10 fold more potent than genistein. This suggests these compounds in swine diets, especially daidzen, could lead to more follicle recruitment and ovulation, potentially increasing litter size.

Estrogens have systemic effects on mammogenic and lactogenic hormones, and direct mammary tissue effects. Walt Hurley (University of Illinois) works on effects of soybean phytoestrogens on the porcine mammary gland. His work involved developing bioassays to give measurable endpoints for phytoestrogen actions. This is a challenging task, as it is necessary to develop a viable cell culture from mammary tissue that adequately represents what happens in the live animal. Considerable effort went into exploring cell culture models for mammary cell growth, with mixed results, and the mammary cell growth experiments await a suitable model.

Lactogenesis experiments used treatments with genistein, quercetin (a tyrosine kinase inhibitor), or no inhibitor. While genistein and quercetin inhibited amino acid lysine uptake and total protein synthesis, the genistein effect was at higher than normal levels of genistein and these effects were seen in cell cultures, not in a live animal. Further work is needed to confirm these early findings.

Eric Walters and Matthew Wheeler (University of Illinois) work on effects of the phytoestrogen daidzein on embryo development. While phytoestrogens influence the ruminant reproductive systems, little is known about their effects in pigs. Embryo cell cultures treated with various doses of daidzein were observed for embryo development. Data suggest that the development of the porcine preimplantation embryo is unaffected by this daidzein. Blastocysts were stored for RNA isolation for reverse transcription polymerase chain reaction to identify the presences of mRNA for specific growth factors.

Tim Stahly (Iowa State University) showed enhanced body growth rate and muscle content in pigs when diets included a mixture of genistein, daidzein and glycetin. Enhanced muscle growth was observed in predominantly red-fiber muscles, which have more desired meat quality attributes. These responses are associated with lower pork production costs and greater market value of the pigs produced. Dietary additions of soy isoflavones during the dam's pregnancy also improved the offspring's muscle growth and efficiency of feed utilization. The offspring's response was dependent on the amount of isoflavones consumed by the dam.

Objective 4

The level and quality of dietary protein (amino acid balance) affect meat quality. Floyd McKeith and Mike Ellis (University of Illinois) found varying the levels of the amino acid lysine in the diet affected intramuscular fat content, or marbling. Lower than normal levels fed to gilts for five weeks increased marbling. The optimal level that maximized the response was 4.8 g/kg lysine, which is approximately 75% of the estimated requirements. These effects were not seen in pigs fed the altered diets for shorter periods. Further studies found this marbling improvement remained when the pigs were fed the lysine-deficient diet during hot environmental conditions. Even though the pigs saw decreased growth rates due to decreased feed consumption and thus, the lysine, their feed efficiency was improved.

Research Plan of Work–Year 2

The Soy/Swine team leaders met with academic and industry representatives in February 1999 at the University of Illinois. Updates on current projects were discussed, and small groups developed research directions for a plan of work proposed for the 1999-2000 research period.

Participants attending research planning meeting for the program

Year 2 will see modifications in project management. With Objectives 1 and 2 so closely linked during year 1, the team leaders will now work together, with Don Mahan overseeing the animal research and George Fahey directing the analytical work. Together their teams will pursue several lines of research to identify those factors that can influence nutrient utilization.

One area will evaluate the effects of processing methods on amino acid digestibility. The presence of soapstock, clays, abnormal calcium:phosphorus ratios, and gums will be examined. Other experiments may evaluate the effects of dietary components routinely added to soybean meal, such as crude soybean oil, weed seeds and enzymes.

Also proposed: continued comparisons of soybeans from the U.S., Brazil, India and China. Expanded sampling within the U.S. will provide a more comprehensive look at domestic meal quality and a processing nutritional index for each maturity region. Samples from other countries would include beans and meal processed in the home country for nutritional analyses and ileal digestibility studies. These studies will demonstrate effects of processing methods within each country on nutrient digestibility.

Todd Winters and Tim Stahly continue to oversee projects under Objective 3. Three areas of research will determine the added value of bioactive compounds in soy products on reproduction capacity, disease resistance, and muscle growth/meat quality in pigs. The amounts and variability in the bioactive compound content of soybean meals from different countries and processing techniques also will be determined.

The effects of soy bioactive compounds on the key reproductive functions of ova formation and viability, embryo development and mammary functionality will be determined. Specifically, the effects of isoflavones and other soy estrogens on ovarian follicular metabolism and cell death will be investigated. The effects of isoflavones on cell-signaling critical to embryo development also will be elucidated. The mammary in vitro studies in year 1 suggested year 2 work use live animal studies. Ovariectomized gilts will be treated with combinations of genistein and the porcine mammogenic factor relaxin. Mammary glands development will be monitored, with the expectation that treatment with genistein will enhance mammary gland growth.

The value of soy bioactive compounds on enhancing disease resistance in pigs will be determined. Pigs will be fed soy genistein, daidzein, and saponins and then be exposed to viral pathongesn. The soy bioactive compounds at optimum concentrations are expected to enhance elimination of the pathogen and improve subsequent pig performance.

Year 2 will follow up on the muscle growth studies done in year 1 with feeding studies using pregnant sows. The value of soy isoflavones on modifying the subsequent growth, muscle development and feed utilization of the sow's offspring will be determined. These studies will establish the added value of soy bioactive compounds in feedstuffs for pigs.

The meat quality work under Objective 4 led by Mike Ellis and Floyd McKeith will examine how different oil contents in swine diets affect pork quality. The diets to be evaluated will include meal that is solvent-extracted, with one of three levels of soapstocks added, extruded-expelled and full-fat. Slaughter, carcass and meat quality will be evaluated, as well as tenderness, juiciness and flavor of cooked loin chops. Similar evaluations will be done in a trial investigating the extent to which fatty-acid composition of pork can be manipulated using a combination of soybean meal and soybean oil of different fatty-acid compositions.

The economic model for scenario analyses under Objective 5 will be refined by Kelly Zering. Model detail and accuracy will be examined, and modifications made to include foreign demand and supply for soybean products. Year 2 will see the model used to examine alternative scenarios for the U.S. soybean industry's future.

Additional work to address dynamics of the sectors important to the soybean industry (i.e., processing, feed manufacturing, integrated swine) will begin to better allow future technology transfer from the soy/swine research program to pertinent industry participants.

Soy Swine

Nutrition Research Program

National Soybean Research Laboratory
170 Environmental & Agricultural Sciences Building
1101 W. Peabody Drive
Urbana, IL 61801-4723

Research Objectives and Team Leaders

Objective 1 **- Don Mahan, Ohio State University**
Conduct a comprehensive study of the variation in the nutrient content of soybean meal and identify the principal indigenous and processing factors that contribute to incomplete digestion of nutrients.

Objective 2 **- George Fahey, University of Illinois**
Characterize the carbohydrate component of soybean meal and develop strategies for elimination of undesirable carbohydrates and enhanced utilization of those that remain.

Objective 3 **- Tim Stahly, Iowa State University and Todd Winters, Southern Illinois University**
Investigate the effects and determine the value of the bioactive molecules in soybean meal on enhancing reproductive capacity, disease resistance, and muscle growth.

Objective 4 **- Mike Ellis and Floyd McKeith, University of Illinois**
Characterize the effects of soybean meal, relative to other oilseed proteins, on pork quality (color, water-holding capacity, palatability and fat quality).

Objective 5 **- Kelly Zering, North Carolina State University, and Steve Sonka, University of Illinois**
Determine the economic importance of potential changes in soybean meal use relative to its position in domestic and global markets.

The S/SNp newsletter is published by the National Soybean Research Laboratory at the University of Illinois, 170 EASB, 1101 W. Peabody Drive, Urbana, IL 61801; telephone (217) 244-1706; e-mail nsrl@uiuc.edu. Steven T. Sonka, director; Marilyn Nash, editor.

Illinois Soybean Checkoff Board

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