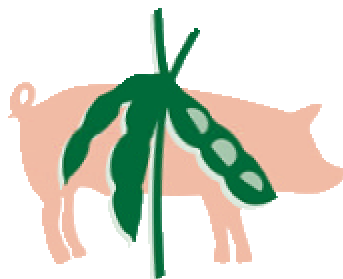


Research Reports
from the
Soy/Swine Nutrition Research Program
1998-1999



Acknowledgements

June 6, 2000

The Soy/Swine Nutrition Research Program is an ongoing program of collaborative research into how soybeans can be better utilized in swine diets. This report compiles research results from seventeen investigators at over a dozen institutions and is organized by research objective area. The cooperation of each investigator submitting their report for this document was appreciated.

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Executive Summary
Soy/Swine Nutrition Research
Spring 2000

The Nutrient Composition and Digestion team worked to:

- measure the variation in the nutrient content of soybean meal processed within a single processing plant during the course of a single harvest season; and
- to determine the apparent and true amino acid digestibilities in these samples.
- Ileal digestibility studies compared a common source of soybean meal, a locally procured meal, soy protein concentrate, and a casein, low protein diet.
- These trials suggest amino acid digestibilities vary by regions and/or processor. The reasons for these variations may be due to genotypes, processing conditions, or their interaction.
- True ileal digestibilities of amino acids in soybean meal and soy protein concentrate are not 100%, providing future opportunities to increase digestibilities and/or decrease endogenous amino acid losses in pigs fed soy products.

The work by the Carbohydrate Utilization team consisted of:

- Comparing quality characteristics of soybeans from Brazil, China, and the United States,
- Identifying compositional characteristics of U.S. beans and meal from processing plants,
- Reviewing the effects environment and management have on soybean seed composition,
- Examining how soybean products affect nitrogen and phosphorus excretion and volatile organic compound concentrations.
- International bean samples showed significant, but small, differences in several components within a country. U.S. samples had the most consistent amino acid contents.
- Differences were seen among countries in several components. Soybeans from the U.S. had the highest concentrations of total essential, nonessential, and total amino acids.
- Fall, winter, and spring soybean and meal samples from U.S. processing plants were analyzed for compositional characteristics.
 - There were significant variations between processing plants in most meal characteristics analyzed, including gas production and fermentation.
 - Across seasons, beans differed in several characteristics, but only lysine concentrations differed in the meal. Season had less effect on gas production and fermentation than did processing plant.
- Processing introduces compositional variability in characteristics that impinge on the quality and nutritive value of soybean meal. The desolventizing-toasting stage, in particular the toasting temperatures and duration of heat treatment, have the greatest effect on meal quality.
- The extensive literature review summarizes the general responses of soybean nutritional components to environmental conditions and management factors such as temperature, photoperiod, soil fertility, pH, planting date and pattern, etc.
- Recommended areas for future research include:
 - Genotype development to achieve consistent target levels of protein and oil,
 - Genotype development with improved feed or end-use value,
 - Improvement of the capability to predict levels of seed components across environments.
- Soybean meal contributes less to dry matter and nitrogen excretion than does the corn in a typical corn-soybean meal diet. As the refinement of the soybean in the diet increases, dry matter and excretion are reduced.

The Bioactive Compounds team examined soybean meal isoflavone effects on reproductive and growth characteristics. Ovulation propensity, embryo survival, and lactogenesis were done with in vitro work. Isoflavone effects on estrous and growth and muscle development were done using pigs and rats.

- Daidzein and genistein were shown to decrease apoptosis, with daidzein ten times more potent than genistein. Both were more potent than the animal's natural estrogen, estradiol. These compounds can potentially increase follicle survival, leading to improved litter size.
- Embryos from the 2-cell to hatching stage were collected from gilts and cultured with or without increasing doses of daidzein. There was no significant difference in the formation of blastocysts for all but one treatment dose of daidzein, compared to the controls.
- Genistein present at levels consistent with those typically found in swine diets had no negative effect on indicators of lactogenesis.
- Isoflavones fed to littermate were shown to increase body weight, percentage carcass muscle, and weight of red-fibered muscles but not affect daily feed intake and gain:feed ratio.
- Isoflavones fed to pregnant rats were shown to be bioavailable to the pregnant rats, and detectable in fetal tissues. Female offspring were more efficient in feed utilization and had improved growth rate. In males, the hind limb muscle content increased.

The Meat Quality team compared growth, carcass traits, and pork quality and sensory data in pork from pigs fed different protein sources.

- Soybean meal was compared to amino acids, dry extruded soybeans, canola meal, peanut meal, sunflower meal, cottonseed meal, peas, meat/bone meal or poultry by-product meal.
- Pigs fed the amino acid diet had decreased growth performance and carcass muscling, and increased carcass fat content. A similar, but not as severe response was seen in pigs fed the animal source protein.
- The other plant source proteins were not better than soybean meal, but some were similar, namely the dry extruded soybeans diet. However, these pigs had pork quality sensory data indicative of the higher level of fat in these diets.

The Economics Analysis team developed a model of U.S. soybean supply and demand in the world market to determine the economic importance of potential changes in soybean meal use relative to its position in domestic and global markets. The model was used to evaluate five alternative scenarios of changes in the soybean complex in relation to production and marketing, particularly with respect to the pork industry.

- A technical change that either increases the demand for soybean meal by 1 percent, or alternatively, decreases the yield of meal by 1 percent would induce an increase in producer surplus of \$198 million dollars. Almost as effective in increasing soybean producer surplus would be a technical change that increases the demand for soybeans by 1 percent, resulting in an increase in soybean producer surplus of \$182 million.
- Research results from soy/swine research areas will indicate where it may be desirable to pursue fundamental changes in the use of soybean meal in swine diets. The economic model will be an important tool for evaluating such recommendations and will provide valuable information to industry and research decision makers on potential benefits of making such changes.

Executive Summary
Soy/Swine Nutrition Program Year 1

Nutrient Composition and Utilization

- There were two phases of work in this area during 1998-1999. Results from Phase I are reported here; Phase II results will be reported in the next year as projects end.
- The objectives of Phase I work were to
 - measure the variation in the nutrient content of soybean meal processed within a single processing plant during the course of a single harvest season; and
 - to determine the apparent and true amino acid digestibilities in these samples.
- Researchers from five regionally distinct institutions used the same study design for ileal digestibility studies of soybean meal based diets that used:
 - a common source of soybean meal,
 - a locally procured soybean meal from one harvest collected at four different times (days 0, 15, 30 and 45),
 - soy protein concentrate, and
 - casein, low protein diet to estimate endogenous losses of amino acids.
- Results were mixed for the comparisons of apparent and true ileal digestibilities of the amino acids for the soy protein concentrate and the meal based diets. While the Kansas study found the concentrate digestibilities were lower, the Ohio study found the apparent digestibilities were higher, but no difference in true digestibilities. North Carolina and Illinois noted lower apparent digestibility of methionine, probably related to how the concentrate is processed.
- Digestibility of amino acids among diets from Kansas were similar, except for tryptophan, which was lower for the day 30 sample than for samples from other dates. In Illinois, Ohio, and North Carolina, there were no significant differences between samples over time. Overall, apparent and true digestibilities varied little from one collection period to another.
- Results were also mixed for the comparisons of apparent and true ileal digestibilities of the amino acids for the common source and locally procured diets. Kansas found the control meal had higher digestibilities of some amino acids, but Ohio found the control meal had lower digestibilities. Illinois and North Carolina found no significant differences
- These trials suggest there is variation in amino acid digestibilities by regions and/or by processor. The reasons for these variations may be due to genotypes, processing conditions or an interaction between these factors.
- True ileal digestibilities of amino acids in soybean meal and soy protein concentrate are not 100%, providing future opportunities to increase digestibilities and/or decrease endogenous amino acid losses in pigs fed soy products.

Executive Summary
Soy/Swine Nutrition Program Year 1

Carbohydrate Utilization

- Projects undertaken for this objective consisted of:
 - Comparisons of quality characteristics of soybeans collected from Brazil, China, and the United States;
 - Compositional characteristics of U.S. soybeans and meal from processing plants, including in vitro fermentation studies; and
 - Review of the environmental and management impact on soybean seed composition.
 - Examination of how soybean products affect nitrogen and phosphorus excretion and volatile organic compound concentrations.

International soybean comparisons

- Samples from 5 Brazilian states, 6 Chinese provinces, and 15 U.S. states were collected and analyzed for dry matter, organic matter, crude protein, acid hydrolyzed fat, neutral detergent fiber, protein solubility, and amino acid composition. The U.S. samples were grouped according to the maturity zone in which they were produced
- There were significant differences in dry matter, organic matter and ash concentrations within a country, but the differences were generally small. Amino acid content was more consistent between U.S. samples than between Chinese or Brazilian samples.
- In contrast differences were seen among countries in dry matter (U.S. the highest), organic matter (Brazil higher), ash (Brazil lower), crude protein (China and U.S. similar, and higher than Brazil), and protein solubility (U.S. highest). Soybeans from the U.S. had the highest concentrations of total essential, nonessential, and total amino acids.

U.S. processing plant comparisons

- Fall, winter, and spring soybean and meal samples were obtained from 10 U.S. processing plants and analyzed for compositional characteristics.
- Comparing processing plants, there were significant variations in most meal characteristics analyzed, except dry matter, urease activity, lysine and total non-structural carbohydrates. There were also variations were seen in gas production and fermentation.
- Across seasons, beans differed only for organic matter, lysine, acid hydrolyzed fat, protein solubility, neutral detergent fiber, and protein dispersibility. Meal differed only in lysine concentrations. Gas production and fermentation were less affected by season than by processing plant.
- Processing introduces compositional variability in characteristics that impinge on the nutritive value and quality of soybean meal. The desolventizing-toasting stage, in particular the toasting temperatures and duration of heat treatment, have the greatest effect on meal quality.

Literature review

- The extensive review summarizes the general responses of soybean nutritional components to environmental conditions and management factors such as temperature, photoperiod, soil fertility, pH, planting date and pattern, etc.
- Recommended areas for future research include:
 - Genotype development that achieve target levels of protein and oil across environments and years;
 - Genotype development with improved feed or end-use value
 - Improvement of the capability to predict levels of seed components across environments.

Nitrogen and phosphorus excretion

- In one study, four diets were compared for levels of nitrogen and phosphorus excretion. A control diet intended to minimize excretion was compared with diets where corn, soybean meal, or both corn and soybean meal were introduced.
- Soybean meal contributed less to dry matter and nitrogen excretion than did the corn in a typical corn-soybean meal diet. Of course, pigs fed the soybean meal diet excreted more dry matter, nitrogen, and phosphorus than pigs fed the diet designed to minimize excretion, but this was less than those pigs fed the corn diet.
- In the second study, comparisons in excretion were made between pigs fed diets with different soy products; soybean meal, soybean hulls added to the meal, soy protein concentrate, and soy protein isolate.
- As the refinement of the soybean increased, dry matter and excretion were reduced. Total organic compounds in the slurry were similar between diets, but dry matter excretion was highest for pigs fed the diet with hulls added. Total nitrogen excretion was highest for pigs fed the hull diet, similar for diets using soy protein concentrate or soybean meal, and lowest for the protein concentrate diet.

Executive Summary
Soy/Swine Nutrition Program Year 1

Bioactive Compounds

- Bioactive compounds in soybean meal were examined for effects on reproductive and growth characteristics. Ovulation propensity, embryo survival, and lactogenesis were done with in vitro work. Isoflavone effects on estrous and growth and muscle development were done using pigs and rats.
- Cultured porcine granulosa cells were treated with varying concentrations of genistein, daidzein, diethylstilbestrol, or estradiol to measure the effects on cell apoptosis (the natural programmed cell death).
- Daidzein and genistein were shown to decrease apoptosis, with daidzein ten times more potent than genistein. Both were more potent than the animal's natural estrogen, estradiol. These compounds can potentially increase follicle survival, leading to improved litter size.
- Synchronized breeding age gilts were fed diets prepared that lacked isoflavones, saponins, and phytosterols, or had standard soybean meal with these compounds present. Blood samples were taken for baseline measures and then at 15-minute intervals over 24 hours. Data have been collected to date, but analysis is still ongoing.
- Embryos from the 2-cell to hatching stage were collected from gilts and cultured with or without increasing doses of daidzein. There was no significant difference in the formation of blastocysts for all but one treatment dose of daidzein, compared to the controls. At 3 uM of daidzein, there was at trend for improved blastocyst development.
- A bioassay to determine the tissue-level effects of isoflavones on mammary cell development and lactation was emphasized. Problems encountered in developing a tissue culture system to measure mammary tissue growth meant work move to characterizing the effects of genistein as a potential tyrosine kinase inhibitor on lactogenesis. Genistein present at levels consistent with those typically found in swine diets had no negative effect on indicators of lactogenesis.
- Littermate gilts were fed diets with varying levels of isoflavones to measure their effects on carcass muscle content and body growth rate. While isoflavones increased daily body weight, daily feed intake and gain:feed were not affected. Isoflavones increased the percentage carcass muscle and estimated muscle gain/day, but did not affect percentage carcass fat. Isoflavones increased the weight of predominantly red-fibered muscles.
- Pregnant rats were used as a model to determine the effects dietary isoflavones have on growth and muscle development in offspring. The isoflavones were shown to be bioavailable to the pregnant rats, and were detectable in fetal tissues. The effect of the isoflavones fed to the pregnant rat were mixed. Female offspring were more efficient in feed utilization and had improved growth rate. In males, the hind limb muscle content increased. For the mother rat, body weight decreased with increasing isoflavone content up to the fourth day of lactation.

Executive Summary

Soy/Swine Nutrition Program Year 1

Meat Quality

- Three studies were done that compared major protein sources to soybean meal, and examined the effects of adjusting lysine levels on meat quality. Growth, carcass traits, and pork quality and sensory data were measured.
- The protein source trials had pigs fed to slaughter weight with diets that replaced a standard corn-soybean meal with diets using another protein source: crystalline amino acids, dry extruded soybeans, canola meal, peanut meal, sunflower meal, cottonseed meal, peas, meat and bone meal or poultry by-product meal.
- Pigs fed the amino acid diet had decreased growth performance and carcass muscling, and in increased carcass fat content. A similar, but not as severe response was seen in pigs fed the animal source protein.
- The other plant source proteins were not better than soybean meal, but some were similar, namely the dry extruded soybeans diet. However, these pigs had pork quality sensory data indicative of the higher level of fat in these diets.
- The lysine feeding trials fed diets deficient in lysine to late finishing stage pigs to determine the effects on carcass fat levels and eating quality of the pork. Trials varied how long the lysine deficient diet was used.
- In general, the results were mixed when the varying times of feeding the lysine deficient diet are compared. In one study though, pigs fed a diet with lower lysine levels (4.8 g/kg) for five weeks increased intramuscular fat, but there was a slower growth rate during this period.
- The lysine deficient diets were further studied under thermo-neutral and hot conditions. Diets with 4.6 g/kg (deficient) or 6.4 g/kg (normal) lysine were fed 5 or 7 weeks under one of the two environments. Again, the lysine deficient diet improved intramuscular fat content, under either condition.
- Dietary lysine content did not affect feed intake or average daily gain, but the lysine-deficient diet pigs had a poorer gain:feed ratio. High environmental temperature decreased feed intake and average daily gain, but improved the gain:feed ratio.

Executive Summary

Soy/Swine Nutrition Program Year 1

Economic Analysis

- A model of U.S. soybean supply and demand in the world market was developed to determine the economic importance of potential changes in soybean meal use relative to its position in domestic and global markets.
- The model was used to evaluate five alternative scenarios of changes in the soybean complex in relation to production and marketing, particularly with respect to the pork industry. These included:
 - A technological change that increases soybean meal demand by 1%,
 - A technological change that increases export demand for soybean meal by 1%
 - A technological change that increases supply of soybeans by 1%
 - A decrease in the soybean crushing margin of 1%
 - A 1% Decrease in the Yield of Meal Due to No More Gum Added
- An intrinsic characteristic of the soybean market is production of joint products from the soybean, i.e., processing of meal and oil. An understanding of the economics of joint products and incorporation of these effects into the model are essential and are incorporated in the model.
- The most enhancing scenario for soybean producers was a technical change that increases the supply of soybeans by 1 percent, which would increase soybean producer surplus by \$408 million. A technical change that either increases the demand for soybean meal by 1 percent, or alternatively, decreases the yield of meal by 1 percent would induce an increase in producer surplus of \$198 million dollars. Almost as effective in increasing soybean producer surplus would be a technical change that increases the demand for soybeans by 1 percent, resulting in an increase in soybean producer surplus of \$182 million.
- The estimated producer welfare effects depend critically on the estimated demand and supply elasticities that were generated by the econometric estimation. Some care must be taken drawing conclusions concerning the magnitudes, and the ordering of the estimated benefits to soybean producers, given this dependence on the demand and supply elasticities.
- Further investigation and some sensitivity analysis of these results will afford some more precise statements concerning the robustness and precision of estimated benefits. Nonetheless, the overwhelming evidence to date suggests that there are indeed some scenarios that have been identified as important, that would result in sizeable economic benefits to U.S. soybean producers. Future scenarios may be derived from Soy/Swine results from other research areas.