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VALUE OF FEED PEAS TO SWINE DIETS

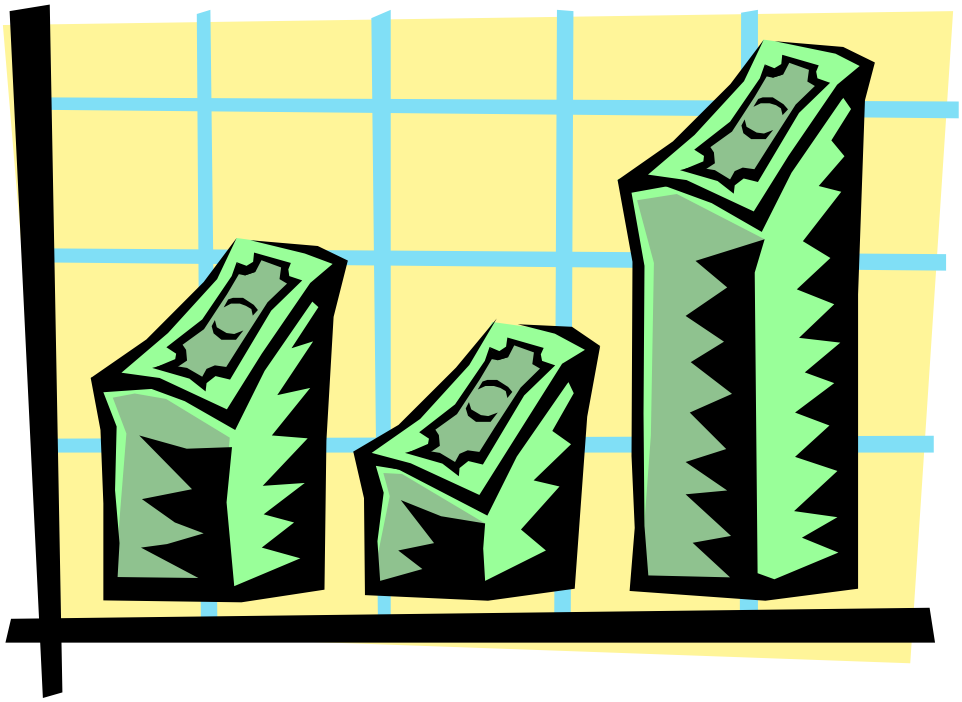

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

ABSTRACT

Traditionally, hog production has been concentrated in the Corn Belt region of the United States. During the past decade, North Carolina has become an important hog production state and now ranks second only to Iowa. More recently, expansion in the U.S. hog industry has been in other non-traditional hog production states in the west/west central regions of the United States. In the current study, field peas are considered as a least-cost hog ration ingredient in three U.S. markets. The results of a linear programming analysis suggest that peas can be an attractive alternative as a feed ingredient in hog diets. Even at relatively high prices, peas can be part of the least-cost diet replacing feedstuffs such as corn, barley, and soybean meal. Except at high pea prices or under low-cost periods for alternative feedstuffs, peas constituted up to 39 percent of a least-cost diet for young pigs including a methionine supplement. Peas constituted 27 to 36 percent of the diet for hogs in the 190 to 260 pound growth stage. It was not necessary to add methionine to a diet for finishing hogs that includes peas. The high lysine content of peas is beneficial. It had to be added to the diet when peas were not included.

Key Words: feed peas, swine diets, least-cost rations, linear programming

HIGHLIGHTS

Peas are an attractive alternative as a feed ingredient in hog diets. Even at relatively high prices, peas can be part of a least-cost diet replacing corn, barley, and soybean meal.

- Except at high prices or under low-cost periods for alternative feedstuffs, peas constituted up to 39 percent of the diet for pigs in the 50 to 80 pound weight category.
- Although previous research has suggested a limit to inclusion of peas in a ration because of their relatively low level of methionine, this amino acid can be added as a supplement. There are no anti-nutritional factors that would make it necessary to limit the inclusion of peas in the diet.
- For hogs ranging from 80 to 140 pounds, peas account for 36 to 42 percent of the diet under typical prices.
- Peas account for up to 54 percent of a least-cost diet for hogs from 90 to 140 pounds.
- Peas constitute 27 to 36 percent of a diet for hogs in the 190 to 260 pound growth stage.
- The high lysine content of peas is beneficial. When the price of peas is too high for it to be included in the diet, it is necessary for lysine to be added as a supplement.

The average feed pea price in North Dakota during the 1998 to early 2000 time period was $3.50 per cwt. The ten-year average (1986 to 1995) was $5.88 per cwt.

- At a price of $3.50/cwt, a least-cost diet consists of 39 percent peas for 50 to 80 pound hogs, even if the prices of other feedstuffs varied by as much as one standard deviation in either direction. In a diet for 80 to 140 pound hogs, 52 percent consists of peas, even under one standard deviation change in the prices of the other feedstuffs.
- For 140 to 190 pound hogs, 54 percent of the diet consists of peas using the two-year average prices for other diet ingredients. Changes in the price of soybean meal do not affect this solution, nor does decreasing the prices of corn and barley. However, a one standard deviation increase in corn and barley prices would increase inclusion of peas in the diet to 63 percent.
- For finishing hogs between 190 and 260 pounds, 36 percent of a least-cost diet consists of peas. If prices of corn and barley increased by one standard deviation and all other prices remained the same, inclusion of peas increases to 71 percent.

Shadow prices of the binding constraints in the LP problem along with the composition of the pea indicate which characteristics of the pea give it value.

- For 50 to 80 pound pigs in North Dakota, the constraints for minimum digestible energy, crude protein, calcium, phosphorous, and methionine are binding. Digestible energy and crude protein, in particular give the pea value in this diet. Increasing the content of any of these characteristics in the pea would increase its value. Increasing the lysine content of peas would not increase their value for young pigs.
- In the diet for 80 to 140 pound hogs, the value of peas comes from digestible energy, calcium, methionine, and tryptophan. Tryptophan and digestible energy provide the most value.

- The same nutrients plus phosphorous give the pea value for feeding hogs in the 140 to 190 pound growth phase.
- Digestible energy, calcium, phosphorous, and tryptophan are the qualities that give peas value as a feed ingredient for 190 to 260 pound hogs.

Value of Feed Peas to Swine Diets

Cheryl J. Wachenheim and Jeremy W. Mattson[1]

INTRODUCTION AND OBJECTIVES

The field pea has a number of agronomic characteristics that make it an attractive alternative crop for the Northern Plains states of the United States and several Canadian provinces. For example, field peas can substitute for, or be a profitable addition to, wheat rotations. Incorporating peas into a crop rotation can help break up disease cycles in wheat rotations, improve soil structure, add nitrogen to the soil, and reduce insect populations (peas break up the cycle of organisms that cause problems in wheat, such as orange wheat blossom midge, leaf diseases, and head scab). Field peas have also yielded well in North Dakota, and are relatively easy to establish. Wheat growers need little additional equipment to grow field peas, although some equipment modifications or attachments are useful.

The field pea is particularly well suited for cool, semi-arid climates. Optimum yields result at growing temperatures between 55 and 65 F (Sell, 1993). Most of the field peas in the United States are grown in the Pacific Northwest. The Prairie Provinces of Canada are also major producers of field peas and peas have also been successfully grown in the northern states of the upper Midwest.

While production of field peas is well suited for the Northern Plains, finding a market for them has been a continuing challenge. As the structure and competitive environment of production agriculture continue to evolve, it becomes increasingly necessary for producers to identify and evaluate innovative marketing alternatives for their commodity. Because of their nutritional characteristics and palatability, field peas are appropriately considered as an alternative feed for livestock. If peas have promise as a low-cost feed alternative, exploration of such potential markets may result in additional opportunities to profitably produce them in North Dakota and Canada. Assigning a value to peas as a component of livestock rations for producers in feed deficit and other regions will help the industry in their development of promotional and educational materials for livestock producers and those who influence their choice of feedstuff. Identification of the value of individual nutritional components of peas (e.g., protein, energy, and minerals) will help the industry target breeding efforts with good potential to increase demand for peas as a component of livestock rations. As such, this study was undertaken with the following objectives: 1) identifying feed deficit regions in the United States, 2) determining the value of field peas as a ration ingredient in swine diets, and 3) identifying the most valuable nutritional components of peas for this use.

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REVIEW OF THE LITERATURE

An information search and literature review were conducted to summarize the current state of knowledge regarding the use of field peas in swine rations and to identify feed deficit regions in the United States.

The Use of Feed Peas in Swine Rations

There is a wide body of literature supporting the use of feed peas as an important component of swine rations throughout the United States.

Nutrient Composition of Peas

Peas are attractive as an alternative feed. The high digestible energy content of peas makes them an important energy source (Rasz and Bell, 1997). Peas are also a high quality protein source. The average crude protein content of feed peas is 22.6 percent. Digestibility of crude protein in peas is high, reported at 83 to 86 percent for swine (Rasz, 1997). Peas have high levels of the important amino acids, with the exception of the sulfur-amino acids (methionine and cystine). Peas have a high concentration of lysine, in contrast to cereal grains and some protein sources that have less lysine but are rich in methionine and cystine (Rasz, 1997). This suggests that peas could be used as a complement with some feeds such as canola meal. The level of lysine in peas is greater than in common feeds such as corn and barley, but less than in soybean meal. Peas have a relatively low ash content. Like most cereal grains, peas are low in calcium but have a good supply of phosphorus. Not much is known about the vitamin content of peas, but it is expected that it is similar to that of cereal grains and other feeds. Some anti-nutritive factors have been found in peas, but the levels do not appear to be very high and are not a practical concern (Rasz, 1997).

Use of Peas in Swine Diets

A number of studies have experimented with peas in swine diets. Most studies suggest that the use of peas does not have a significant adverse effect on performance and that peas have potential as a viable feed alternative in weanling, growing–finishing, and sow rations. The literature supports the hypothesis that the performance of weanling pigs is not adversely affected by the inclusion of peas in the diet. In a study in North Dakota at the Dickinson Research Extension Center, Landblom and Poland (1997a) fed raw and extruded field peas as replacements for corn and soybean meal to weanling starter pigs weighing from 11 to 16 pounds. They found that feeding more than 20 percent pea grain to the freshly weaned pigs had a significant adverse effect on pig performance. They thus recommend that very small pigs should not be fed raw peas. However, they state that in a properly balanced diet, 20 percent pea grain can be used to replace soybean meal and corn once pigs have attained minimum weights of 16 to 20 pounds. They compared their results to those of Canadian researchers who suggested peas constitute a maximum of 15 percent of the weanling ration. When extruded peas are used, Landblom and Poland found that weanling pig performance improved relative to raw peas, but that their use must also be restricted and recommend no more than 20 percent of the ration consist of extruded peas.

Kehoe et al. (1995) conducted an experiment in Canada using field peas in weanling diets at levels up to 20 percent of the diet. The inclusion of peas did not significantly affect pig performance. They concluded that pigs weaned at three or four weeks of age may be fed diets containing raw ground peas at levels up to 20 percent without loss of performance. Gatel et al. (1989) experimented with the use of peas as a ration component for pigs weaned at four weeks of age. Pigs were given either the control diet of soybean meal or a diet containing spring peas with or without a DL-methionine supplement. Performance was the same for pigs fed the control ration and those including peas without the supplement. Those fed the pea diet plus DL-methionine performed better. Bohme (1988) concluded that peas could be included in up to 30 percent of the diet of piglets 22 to 55 pounds.

A number of experiments have been conducted on the effect of the inclusion of peas in the diets of grower-finisher pigs. Edwards et al. (1987) found that peas could be used as up to 30 percent of the grower-finisher diet without adverse effects. They note that ingredient analysis is important and that varietal differences must be considered. The nutrient composition of peas is subject to natural variability due to environment and genetics. In an experiment in Australia, Davies (1984) obtained satisfactory results when growing-finishing pigs were fed diets containing up to 28 percent peas, but growth rates were less when the diet contained 53 percent peas. In a Finnish study, Valaja et al. (1993) fed pigs from 55 to 231 pound diets consisting of one-third peas and two-thirds rapeseed, and added synthetic lysine and threonine. They found daily gain and the feed conversion ratio were unaffected when compared with traditional rations. Matre et al. (1990) conducted a study feeding 55 to 220 pound pigs diets containing 0 to 36 percent pea meal replacing soybean meal. Pigs accepted diets containing 10 or 20 percent pea meal. There were no differences in growth rate or feed conversion between the groups. Diets containing greater amounts of pea meal did not perform as well as those with soybean meal, but were improved upon by adding DL-methionine, L-lysine, and L-threonine or by adding 3 percent herring meal or 9 percent rapeseed meal. In a review of Swedish studies, Thomke (1986) concluded that live performance was not adversely affected when peas replaced barley and soybean meal on an equal lysine basis in diets fed to pigs 44 to 231 pounds, though their results suggest that carcass quality might be reduced. Ogle and Hakansson (1988) concluded, in a summary of Norwegian studies, that when the level of dietary peas increased to the point where adverse effects occurred, supplementation with methionine usually solved the problem.

In North America, the use of peas in excess of 30 percent of the ration appears to be practical. Landblom and Poland (1997b) evaluated feeding pea grain to growing-finishing pigs. The starting weight for pigs in the trials was 50 pounds and the average slaughter weight was 265 pounds. The pigs were fed in four phases. The first three phases contained 40 percent raw pea grain and the last feeding phase contained 35 percent raw pea grain. Results showed that pea grain is an ideal replacement for soybean meal as a source of supplemental protein in the growing-finishing diet. Pig performance, when fed either soybean meal or field peas, was similar for daily gain and feed to gain. Pigs fed field peas, though, ate less daily feed and had lower feed cost/pound of gain and subsequently lower feed cost/head. The lower cost for locally grown pea grain and the more efficient growth of pigs fed peas contributed to the lower cost of production with field peas.

Bell and Wilson (1970) used field peas to replace fishmeal-soybean meal as the protein supplement in grower-finisher diets. Pig performance was not negatively affected by the use of field peas. They found satisfactory performance from diets containing 40 percent cull peas. No benefit was found from adding methionine to the diet containing 24 percent peas, though other studies have found positive responses to methionine and tryptophan supplements. Madsen and Mortenson (1985), for example, indicate that diets containing greater than 20 percent peas should include methionine, threonine, and tryptophan supplements to prevent deterioration in pig performance.

The results of a Canadian study (Castell and Cliplef, 1993) confirmed that canola meal and pea meal were complementary sources of supplementary amino acids for growing-finishing pigs. In another Canadian study, Castell et al. (1988) fed pea screenings as a replacement for soybean meal to barrows from 54 pounds to slaughter weight. They found that growth rate and feed conversion efficiency were not affected by diets containing up to 33 percent pea screenings. In an experiment conducted in North Dakota, Harrold et al. (1999) concurred, concluding that combinations of ground wheat screenings, field peas, and canola seed could be used effectively by growing-finishing swine.

The high protein quality and high digestible energy of peas also make them useful in lactating sow diets (Rasz and Bell, 1997). In a European study, no differences were found in wheat-corn sow diets when peas completely substituted for soybean meal as a supplemental protein source (Gatel et al., 1987). They concluded that the use of peas in sow diets should only be limited by cost. In a study in Germany, Leitgeb et al. (1994) found that inclusion of peas as 10 percent of the diet for breeding sows had a positive effect on litter size and number of weaned piglets. Inclusion of 20 percent peas gave indifferent results while inclusion of 30 percent tended to decrease litter size and the number of weaned piglets. They suggested that if diets with more than 20 percent peas are fed, methionine supplementation should be considered. Gatel et al. (1988) studied the effect of pregnancy and lactating diets containing 16 percent and 24 percent white flowered smooth-seeded spring peas as a substitute for wheat, barley, and soybean meal in Large White first litter sows. They found no adverse effects on appetite, weight, reproductive performance, or breeding lifetime of sows. They concluded that spring peas may be used in the diet for breeding sows. Ogle and Hakansson (1988), however, report that Scandinavian studies suggest that moderate levels of peas in gestation and lactation diets may reduce litter size and weaning.

Overall the literature support the use of peas in diets of pigs from weaning to slaughter weight and sows, although it may be necessary to supplement amino acids to achieve optimal performance rates.

Feed Deficit Areas

Hog Production

Hog production has been traditionally concentrated in the Midwest, with Iowa long being the number one hog producing state. Today, Iowa still leads the nation in hog inventories. There were 15.1 million hogs in Iowa on December 1, 2001. Four of the top five states in hog inventory were in the Midwest including Iowa, Minnesota with 5.7 million, Illinois with 4.3

million, and Indiana with 3.2 million. Hog production in these states has remained fairly constant for a number of years, though Illinois and Indiana have experienced some reduction in hog production and Minnesota has seen a slight increase. However, in recent years hog production has shifted to non-traditional production regions. Most notably, during the past decade, North Carolina was the fastest growing hog producing state. In the early 1970s, North Carolina was not even among the top ten hog producing states. In 2001, with 9.6 million hogs, it claimed over 16 percent of hog and pig inventory in the United States and ranked second.

In the past, concentration of the U.S. hog industry in the major corn producing regions was logical because corn typically has been and continues to be an important component in swine rations. Recently, though, hog production has been shifting away from the Corn Belt and, in most recent years, west towards states such as Oklahoma and Utah. For example, the hog and pig inventory in Oklahoma increased from just 590,000 in 1994 to 2.5 million on December 1, 2001, which ranked eighth among all states. Most of the hog and pig inventory, and most of the growth in inventory in Oklahoma, has been in the panhandle region. The Utah inventory of all hogs and pigs grew from only 27,000 on December 1, 1989, to 62,000 on December 1, 1995, and then grew substantially to 610,000 on December 1, 2001. These areas have a particular advantage for cooperators looking to identify strategic partners as a market for feeds. Hog inventory under ownership by one group and operation size are often very large (for example, Circle Four Farms located in Milford, Utah). The consolidation of ownership and concentration of production has resulted and continues to result in fewer decision makers regarding the rations of hogs produced throughout the United States.

Location of Major Feedstuffs

Corn is one of the most common feedstuffs in a hog diet. The major corn producing states are Iowa, Illinois, Nebraska, Minnesota, and Indiana (each traditionally a major hog producing state). Barley is another feedstuff used in hog diets. The major barley producing states are North Dakota and Montana. Neither state is a major hog producing state. In fact, North Dakota hog inventory has been declining in recent years; hog and pig inventory in North Dakota was 154,000 in 2001, which is the lowest it has been in 100 years [National Agricultural Statistics Service (NASS)]. Idaho, Washington, and Minnesota are also significant producers of barley. Washington was only among the top fifteen states (thirteenth) in cattle and calves; Minnesota was third in hog inventory, fifth in milk cow inventory, and tenth in cattle and calves on feed. Sorghum, which can also be fed to hogs, is produced mostly in Kansas and Texas.

In the United States, the commodity under consideration, field peas, has predominately been grown in the Palouse region of Idaho, Washington, and Oregon. Peas are also produced in Minnesota, North Dakota, and Montana. Western Canada, especially Saskatchewan and Alberta, is also a major production region for peas.

Reconciliation of Pork and Feed Production

Traditionally, perhaps the most important factor, location of major feed producing regions, has declined in influence on the location and growth of pork production and livestock production in general. Other factors including land and labor availability have become increasingly important. The result is growth in the hog industry in feed deficit regions.

Of the major hog producing states today, North Carolina (the second largest hog producing state) is the one located in a feed deficit region. The remainder of the major hog producing states as measured by production and inventory (versus growth or the existence of one or more operations suitable for strategic partnership with pea producers), are located in the Corn Belt. Iowa is first, Minnesota is third, Illinois is fourth, Indiana is fifth, Missouri is sixth, and Ohio is tenth. Nebraska (seventh) and Kansas (ninth), Northern Plains states, and Oklahoma (eighth), a Southern Plains state, round out the top ten. Oklahoma and Utah, while not yet major hog producing states, can also be considered as feed deficit regions. As noted earlier, hog production has increased considerably in the western region during the past few years. If hog production continues to shift west into feed deficit regions, more of the commodities feeding our nation's hogs will be imported from other states and provinces. In sum, the states that are current or potential feed deficit regions are also the states that have experienced the highest growth in hog production. Today, North Carolina, Oklahoma, and potentially, western and northwestern states, are or will likely become the major feed deficit regions.

METHODS

Identification of feed deficit regions was used, along with advice from university and hog industry experts to specify three locations at which to value field peas in hog rations. Within the general regions identified, specific locations at which feed price data were available were chosen. The specific locations represent the feed deficit state of North Carolina, which was second in hog inventory in 2001 with 9.6 million hogs, and Oklahoma, number eight in hog inventory with 2.5 million hogs in 2001 and one of the leading states in hog inventory growth. Consideration of North Dakota provides a local point of comparison.

The value of field peas in hog rations is influenced by the nutrient needs of the hog, the cost of alternative feedstuffs, transportation cost from the point of production to hog production site(s) under consideration, and any other factors that influence the operation's ability and willingness to use peas in the ration. The nutrient needs of the hog and the cost of alternative feedstuffs are included in this analysis. Transportation cost from the point of origin to the point of use is not subtracted from the value of field peas in the hog ration to arrive at a point of origin value. Because the point of origin, the transportation mode used, and the specific time period under consideration, will at times greatly affect transportation cost, caution is advised in interpreting results presented. They must be adjusted for transportation to any given point of origin.

The value of field peas for use in hog rations is determined through composition of a least-cost ration for hogs at different stages of growth using prices of alternative feedstuffs (specifically corn, barley, and soybean meal). A linear programming (LP) model is well-suited to a problem including a single performance measure or objective (here to minimize feed cost) and constraints (here the nutritional requirements of the animal) that must be met. Linear programming is a mathematical technique that determines the optimal decision even when there are a large number of variables and linear relationships.

Nutritional Requirements

In determining the least-cost ration for hogs, the objective is to minimize the cost of a diet meeting the specific nutrient needs of the animal at various stages of production. The minimization is subject to a set of hog nutritional constraints. Table 1 lists the nutritional constraints used in the LP problem.

Table 1. List of Nutritional Constraints for Hog Diets (percent of diet unless otherwise noted)

Minimum digestible energy (kcal/lb.)
Minimum crude protein
Minimum calcium intake
Maximum calcium intake
Minimum phosphorus intake
Minimum lysine intake
Minimum methionine intake
Minimum methionine + cystine intake
Minimum threonine intake
Minimum tryptophan intake
Minimum acid detergent fiber
Maximum acid detergent fiber
Salt content
Trace minerals content
Vitamin content
Selenium content
Minimum total intake (pounds/day)

Hog diets, especially in the Midwest and Northern Plains, are conventionally composed of corn and/or barley and soybean meal. These three feedstuffs are included as available options (possible feed ingredients) in the model, along with peas. Soybean meal used in this analysis is 44 percent protein.[2] Trace minerals, vitamin premix, selenium premix, and salt are included to account for nutrient requirements not supplied by feedstuffs. The following synthetic amino acid supplements are also included in the model as potential ingredients in the least-cost ration: lysine, methionine, threonine, and tryptophan. These are included because certain feed ingredients may be desirable but are low in an important amino acid. The literature has identified that peas, for use in swine rations, may be low in methionine. Supplementing peas with synthetic methionine may be less costly than using a different feedstuff that has higher levels of methionine. Lysine is also important because it and methionine are often the most limiting of the amino acids. Peas are high in lysine compared to corn and barley.

[2] An alternative, high protein soybean meal, is 46.5 percent protein. The average price differential during the past two years in the Minneapolis market between low and high protein soybean meal has been $8.17 per ton (*Feedstuffs*, various issues). The appendix includes an analysis run using current prices and a high protein soybean meal (47 to 48 percent protein). When available and economically viable, high protein soybean meal is preferred for hog rations.

Peas are most likely to have value in the diets of growing/finishing hogs. For this study, the growing/finishing hogs are grouped into four growth phases: 50 to 80, 80 to 140, 140 to 190, and 190 to 260 pounds. Separate phases are necessary because nutrient requirements change as a pig grows. Larger pigs need a greater daily intake, but their nutritional requirements are less restrictive. Younger pigs require a greater portion of their diet to consist of protein and amino acids. These four phases were chosen because they have been used in previous feed studies for hogs and, therefore, provide a basis for comparison. Comparison of the demand by pigs in different growth phases reveals that the value of field peas to the ration is, in general, greatest for hogs in the 190 to 260 pound growth phase. Hogs in this growth phase, therefore, comprise the market with the greatest potential to outbid other uses for field peas. Least-cost rations were solved to determine demand for (value of) field peas in the ration for each growth phase, using both digestible and metabolizable energy requirements.

Data

Nutritional requirements are based on National Research Council (NRC) requirements. The CD-ROM included with the NRC's *Nutrient Requirements of Swine: Tenth Revised Edition (1998)* provides nutrient requirements of hogs at any desired weight. Nutrient requirements for the four phases were obtained using this CD-ROM. For each phase, the nutrient requirements of the mid-weight pig are used. For example, the nutrient requirements for animals in the 50 to 80 pound growth stage are actually the nutrient requirements of a 65-pound pig. Nutrient requirements are continually changing as the pig grows, so theoretically an infinite number of nutrient requirements could be obtained. It is logical to use the nutrient requirements of the mid-weight pig. This is close to the average nutrient requirements of all pigs in the phase because the relationship between nutrient requirement and weight is fairly linear. Consultations with experts in animal nutrition at NDSU's Department of Animal and Range Sciences were helpful in devising the technical parameters of the models.

It is necessary to know the nutrient composition of feed ingredients used when diets are formulated to meet the recommended nutrient requirements. The NRC has information on the composition of various feed ingredients, including corn, barley, soybean meal, and peas. The NRC provides information on energy, crude protein, dry matter, acid detergent fiber, vitamin and mineral, and amino acid content of the various feedstuffs. Additional information on barley was obtained from the *1999 Regional Barley Crop Quality Report* from NDSU's Department of Cereal Science (Barr, et al. 1999).

Estimating Demand with the LP Model

An LP model was used to estimate demand for field peas in a hog diet. The analysis is normative in that it is based on an optimization model rather than observed behavior. Johnson and Varghese (1993) used a similar approach in estimating regional demand for feed barley. The objective is to minimize the cost of feeding hogs, using regional feedstuff prices. The minimization is subject to specific nutritional constraints. The demand schedule is derived by varying the price of peas (holding other parameters constant) and re-solving the LP problem. These demand schedules are derived for three specific regions: North Dakota, North Carolina, and Oklahoma. At each location, demand for peas was segregated into the four grower-finisher hog stages.

Pea prices shown on each demand schedule are the prices hog rations could bid for peas in the state under consideration (North Dakota, North Carolina, or Oklahoma). To be meaningful to producers in North Dakota, prices would need to be adjusted by transportation cost to develop a North Dakota bid price. Because transportation costs vary considerably depending on transportation mode (rail, truck, or rail/truck combination), distance hauled, load size and weight, and location (because of, for example, the importance of the availability of back hauls), no effort is made here to adjust prices to a specific location in North Dakota.

Demand is specified for each state and each stage of growth (e.g., 50 to 80 pounds). The demand schedules shown graphically are to be interpreted as the number of pounds of peas in a daily least-cost hog ration for pigs in that stage of growth at each price. The feed pea price is to be interpreted at that location. For example, in the least-cost ration for 50 to 80 pound pigs in North Carolina, at pea prices less than $9.16 per ton, one pig will consume 1.44 pounds of peas per day in a least-cost ration. Multiplying this daily demand by the number of pigs in the weight category and the average number of pigs on feed identifies total demand at that price. Following this same example, at a price of up to $9.16 per ton (in North Carolina), an operation with 10,000 pigs in the 50 to 80 pound weight category year round would demand 5.3 million pounds of feed peas (2,628 tons) for these pigs.

Recent historic prices are used in this analysis to represent the prices of alternative, competing feedstuffs. In the analysis for North Dakota, prices for corn, barley, and soybean meal during 1998 and 1999 are used. This was at the request of the granting agency. The two-year time period represents current market conditions when prices were much lower than historic averages. Five-year historic price averages are used for North Carolina and Oklahoma. Because future prices are not likely to remain at these historic levels but rather will be higher or lower, sensitivity analysis was conducted. In effect, this analysis tells us demand if prices of competing feedstuffs are higher or lower than the average. A one standard deviation adjustment (both up and down) was used. Assuming a standard/normal distribution, historic prices used in calculating the average fell within plus or minus one standard deviation of the average two-thirds of the time. In other words, the range of demand shown between the demand schedules representing a one standard deviation increase and a one standard deviation decrease covers two-thirds of prices observed during the period used to calculate the price for alternative feedstuffs. Increases and decreases in the price of corn and barley are considered simultaneously because the prices of these feedstuffs can be, and in North Dakota are, highly correlated. The price of soybean meal is not highly correlated with either and, therefore, the effect of changes in the price of soybean meal is considered separately in each case.

RESULTS

Demand for Feed Peas in North Dakota

North Dakota is a feed surplus region and is an important barley producing state. Price data for corn and feed barley were obtained from NASS and represent average prices for all of North Dakota during the 1998 to 1999 period. The soybean meal price is the two-year average price in Minneapolis adjusting for (adding) a $13 per ton transportation cost. Soybean meal price data in Minneapolis were obtained from issues of *Feedstuffs*. Prices for the other feed ingredients are based on current market conditions; changes in these prices will not substantially

change the least-cost solution. Table 2 lists the prices of all feed ingredients except peas and the standard deviation for weekly prices of corn, barley, and soybean meal during these two years.

Table 2. Ingredients, Base Case Prices, and Standard Deviations, North Dakota

	Price	Standard Deviation
Feed Barley	$1.38/bu	$0.14/bu
Corn	$1.79/bu	$0.23/bu
Soybean Meal (44 percent)	$153/ton	$20.51/ton
Dicalcium Phosphate	$395/ton	
Limestone	$80/ton	
Lysine	$1.01/lb	
DL-methionine	$1.31/lb	
Threonine	$1.55/lb	
Tryptophan	$201/lb	
Salt	$80/ton	
Vitamin Premix	$3,000/ton	
Trace Minerals	$1,700/ton	
Selenium Premix	$1,000/ton	

The results of the analysis show a strong demand for peas for all four pig growth phases (Table 3, Figure 1). The LP model was first run using the base (average) price for the other feed ingredients. These prices remained constant and the pea price was varied to estimate the demand schedule. Additional models were run varying the prices of corn, barley, and soybean meal. Corn and barley prices can be highly correlated. In fact, the price correlation between corn and barley prices in North Dakota was 0.902 from 1994 to 1999. Thus, to simplify the analysis, models were estimated increasing (decreasing) both of their prices by one standard deviation simultaneously. Soybean meal prices do not tend to be correlated with corn or barley prices. Therefore, additional models were estimated using the base case prices for corn and barley and increasing or decreasing the price of soybean meal by one standard deviation. Results (demand schedules) are discussed for each pig growth phase and shown graphically for the 190 to 260 pound growth phase. Detailed results are shown in Appendix B, Tables B.1–B.4.

Figure 1. Demand for Peas in North Dakota
Average Feedstuff Prices 1998, 99

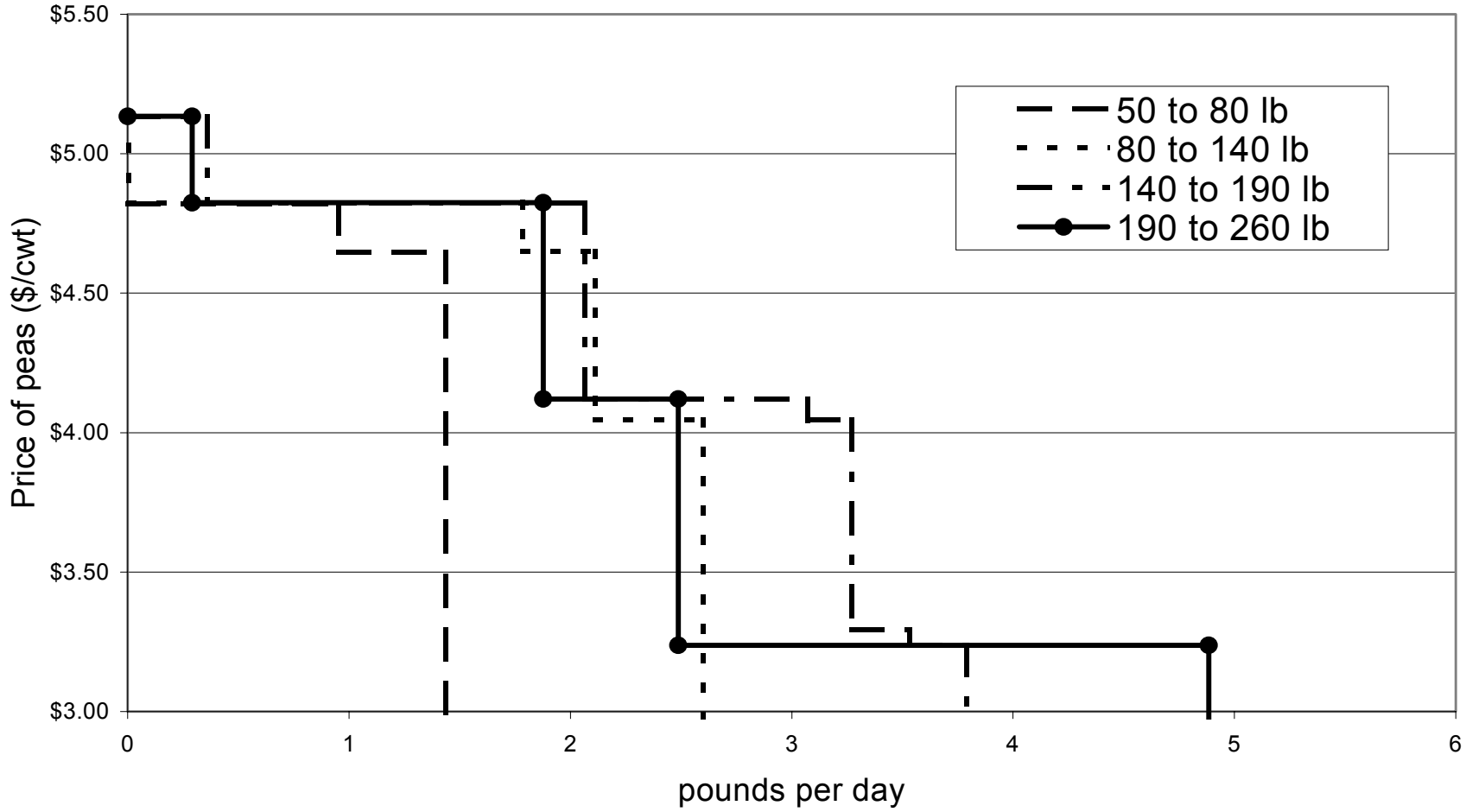


Table 3. Least-Cost Ration Demand for Feed Peas with Base Case Prices for Corn, Barley, and Soybean Meal

	Price range of peas by location ($/cwt)			*Demand for peas in least-cost ration*	
Growth stage	*North Dakota*	*North Carolina*	*Oklahoma*	*lbs/day*	*Percent of diet*
50 - 80 Pound Hogs	< 4.65	< 9.16	< 9.14	1.44	39%
	4.65 to 4.82	9.16 to 9.33	9.14 to 9.31	0.95	26%
	> 4.82	> 9.33	> 9.31	0	0%
80 - 140 Pound Hogs	< 4.04	< 7.45	< 7.34	2.6	52%
	4.04 to 4.65	7.45 to 9.12	7.34 to 9.14	2.11	42%
	4.65 to 4.83	9.12 to 9.29	9.14 to 9.31	1.78	36%
	> 4.83	> 9.29	> 9.31	0	0%
140 - 190 Pound Hogs	< 3.24	< 5.31	< 5.05	3.79	63%
	3.24 to 3.29	5.31 to 5.37	5.05 to 5.10	3.53	58%
	3.29 to 4.04	5.37 to 7.47	5.10 to 7.34	3.27	54%
	4.04 to 4.12	7.47 to 7.55	7.34 to 7.42	3.07	51%
	4.12 to 4.83	7.55 to 9.33	7.42 to 9.31	2.07	34%
	4.83 to 5.14	9.33 to 9.60	9.31 to 9.56	0.36	6%
	> 5.14	> 9.60	> 9.56	0	0%
190 - 260 Pound Hogs	< 3.24	< 5.31	< 5.05	4.88	71%
	3.24 to 4.12	5.31 to 7.55	5.05 to 7.42	2.49	36%
	4.12 to 4.82	7.55 to 9.33	7.42 to 9.31	1.88	27%
	4.82 to 5.13	9.33 to 9.60	9.31 to 9.56	0.29	4%
	> 5.13	> 9.60	> 9.56	0	0%

50 to 80 Pound Hogs

Peas are part of the least-cost solution for 50 to 80 pound pigs at prices below $4.82 per cwt. At prices between $4.65 and $4.82, the least-cost diet consists of 0.95 pounds/day, or 26 percent of the diet. At prices below $4.65, the least-cost diet consists of 1.44 pounds/day of peas, or 39 percent of the expected daily intake of 3.69 pounds.

If the prices of corn and barley are increased by one standard deviation (23 and 14 cents per pound, respectively), peas are part of the least-cost diet at prices below $5.06 and consist of 39 percent of the ration at prices below $4.88. Since prices for corn and barley have been low during 1998 and 1999, an increase in prices is very possible. Peas exit the least-cost diet at prices above $4.59 if the prices of corn and barley are decreased by one standard deviation. Increasing the price of soybean meal by one standard deviation ($20.41/ton) puts peas in the optimal diet with prices below $5.22. If the price of soybean meal is decreased, peas exit the least-cost diet at prices above $4.25.

80 to 140 Pound Hogs

For hogs in the 80 to140 pound weight category, peas are part of the least-cost diet at prices below $4.83. At prices between $4.65 and $4.83, the least-cost diet consists of 1.78 pounds/day of peas, 36 percent of the diet. With prices between $4.04 and $4.65, the least-cost diet consists of 2.11 pounds/day of peas, 42 percent of the diet. At prices below $4.04, the least-cost diet consists of 2.6 pounds/day, or 52 percent of the expected daily intake of 4.99 pounds.

When the prices of corn and barley are increased by one standard deviation, peas became a significant part of the least-cost diet at prices below $5.06. Peas exit the least-cost ration at prices above $4.90 if the prices of corn and barley are decreased by one standard deviation. Peas become a significant part of the least-cost diet at prices below $5.22 when the price of soybean meal is increased by one standard deviation, and at prices below $4.42 when the price of soybean meal is decreased by one standard deviation.

140 to 190 Pound Hogs

For hogs in the 140 to 190 pound weight category, peas are part of the least-cost diet at prices below $5.14. At prices between $4.83 and $5.14, peas constitute a small part of the least-cost diet, 0.36 pounds/day, or approximately 6 percent of the diet. At prices between $4.12 and $4.83, 2.07 pounds/day of peas are part of the optimal solution, which is 34 percent of the diet. With pea prices between $4.04 and $4.12, the least-cost solution contains 3.07 pounds/day of peas, 51 percent of the diet. From $3.29 to $4.04, the least-cost solution contains 3.27 pounds/day of peas, 54 percent of the diet. At prices between $3.24 and $3.29, the optimal solution contains 3.53 pounds/day of peas, 58 percent of the diet. At prices below $3.24, the least-cost diet consists of 3.79 pounds of peas per day, or about 63 percent of the expected daily intake of 6.05 pounds.

When the prices of corn and barley are increased by one standard deviation, peas enter the least-cost diet at prices below $5.37, and comprise 36 percent or more of the ration at prices below $5.06. Peas are no longer part of the optimal solution at prices above $4.90 when the prices of corn and barley are decreased by one standard deviation. In this scenario, peas are 36 percent or more of the diet at prices below $4.59.

Peas are part of the optimal solution with prices up to $5.52 when corn and barley prices are at the two-year North Dakota average and soybean meal prices are one standard deviation higher than the two-year average. They constitute 36 percent or more of the diet in this scenario if prices are below $5.22. When the price of soybean meal is decreased by one standard deviation, peas no longer are part of the least-cost solution at prices above $4.47. Peas are 36 percent or more of the least-cost diet at prices below $4.43.

190 to 260 Pound Hogs

Using two-year average prices, peas are part of the least-cost diet at prices up to $5.13. If the price of peas is between $4.82 and $5.13, the demand for peas in the least-cost solution is 0.29 pounds/day, 4 percent of the diet. At prices between $4.12 and $4.82, the least-cost solution

contains 1.88 pounds/day of peas, 27 percent of the diet. When the price of peas is between $3.24 and $4.12, the least-cost solution contains 2.49 pounds/day of peas, 36 percent of the diet. At prices below $3.24, the optimal solution contains 4.88 pounds/day of peas, 71 percent of the expected daily intake of 6.83 pounds/day

If the prices of corn and barley are increased by one standard deviation, peas are part of the optimal diet at prices up to $5.37 and are a significant part of the diet at prices below $5.06. Peas are no longer part of the least-cost diet at prices above $4.90 if the prices of corn and barley are decreased by one standard deviation. In this case, peas are a significant part of the diet at prices up to $4.53. Increasing the price of soybean meal by one standard deviation puts peas in the least-cost solution at prices up to $5.52 and a significant part of the diet at prices up to $5.22. If the price of soybean meal is decreased, peas are part of the least-cost diet with prices below $4.71 and a significant part of the diet with prices below $4.43. Table 4 shows demand for peas in the least-cost ration for 190 to 260 pound hogs under the base case and alternative price scenarios.

Table 4. Ration Demand for Feed Peas under Alternative Prices for Substitute Feeds, 190 to 260 Pound Growth Stage

Location	Average Prices	Corn / Barley		Soybean Meal	
		+ 1 standard deviation	- 1 standard deviation	+ 1 standard deviation	- 1 standard deviation
North Dakota	5.13 to 3.24	5.37 to 3.63	4.90 to 2.85	5.52 to 3.24	4.71 to 3.24
North Carolina	9.60 to 5.31	10.09 to 6.13	9.11 to 4.51	10.35 to 5.31	8.85 to 5.31
Oklahoma	9.56 to 5.05	10.50 to 6.61	8.91 to 4.02	10.19 to 5.05	8.92 to 5.05

Price range is the price at which peas enter the least-cost diet (at 4 percent, or .29 pounds/day) to the price at which the percentage of the diet comprised of peas is at its maximum (at 71 percent, or 4.88 pounds/day), in dollars per pound.

Demand for Feed Peas in North Carolina

North Carolina hog inventory was 9.6 million on December 1, 2001. The state had over sixteen percent of U.S. hog inventory and was and is a major feed-deficit region. Field peas from the Northern Plains and Canada may be an attractive feed alternative. And, the large operations in this state may be viable strategic partners for marketing large quantities of feed peas.

Prices for corn, barley, and soybean meal in North Carolina were determined using historical data collected from NASS. A five-year average was calculated using data from 1994 to 1998. An average soybean meal price (44 percent protein) from the Appalachian region including Kentucky, North Carolina, Tennessee, Virginia, and West Virginia is used. The prices of other feed ingredients do not have an important effect on demand for peas. Prices of other feed ingredients are the same regardless of region. Table 5 shows prices and standard deviations for corn, barley, and soybean meal in North Carolina.

Table 5. Feed Prices and Standard Deviations, North Carolina 1994 to 1998

	Five-year average price	Standard deviation
Corn ($/bu)	$3.01	$0.47
Barley ($/bu)	$2.14	$0.29
Soybean Meal ($/cwt)	$16.10	$1.97

Table 3 and Figure 2 show demand for peas for use in hog rations in North Carolina. Detailed results are shown in Appendix B, Tables B.5–B.8. Pea prices are those hog rations could bid for peas in North Carolina. Prices will need to be adjusted by transportation cost to develop a bid price for peas originating elsewhere. Because transportation costs vary considerably depending on transportation mode (rail, truck, or rail/truck combination), distance hauled, load size and weight, and location (because of, for example, the importance of the availability of back hauls), no effort is made here to adjust prices to a specific location.

50 to 80 Pound Hogs.

Peas are part of the least-cost ration for 50 to 80 pound hogs at prices less than $9.33. This model assumes an expected intake of 3.69 pounds/day. If the price of peas is between $9.16 and $9.33 in the least-cost ration, pigs consume 0.95 pounds of peas per day, 26 percent of the diet. At prices less than $9.16, the least-cost solution has pigs consuming 1.44 pounds/day, about 39 percent of the diet.

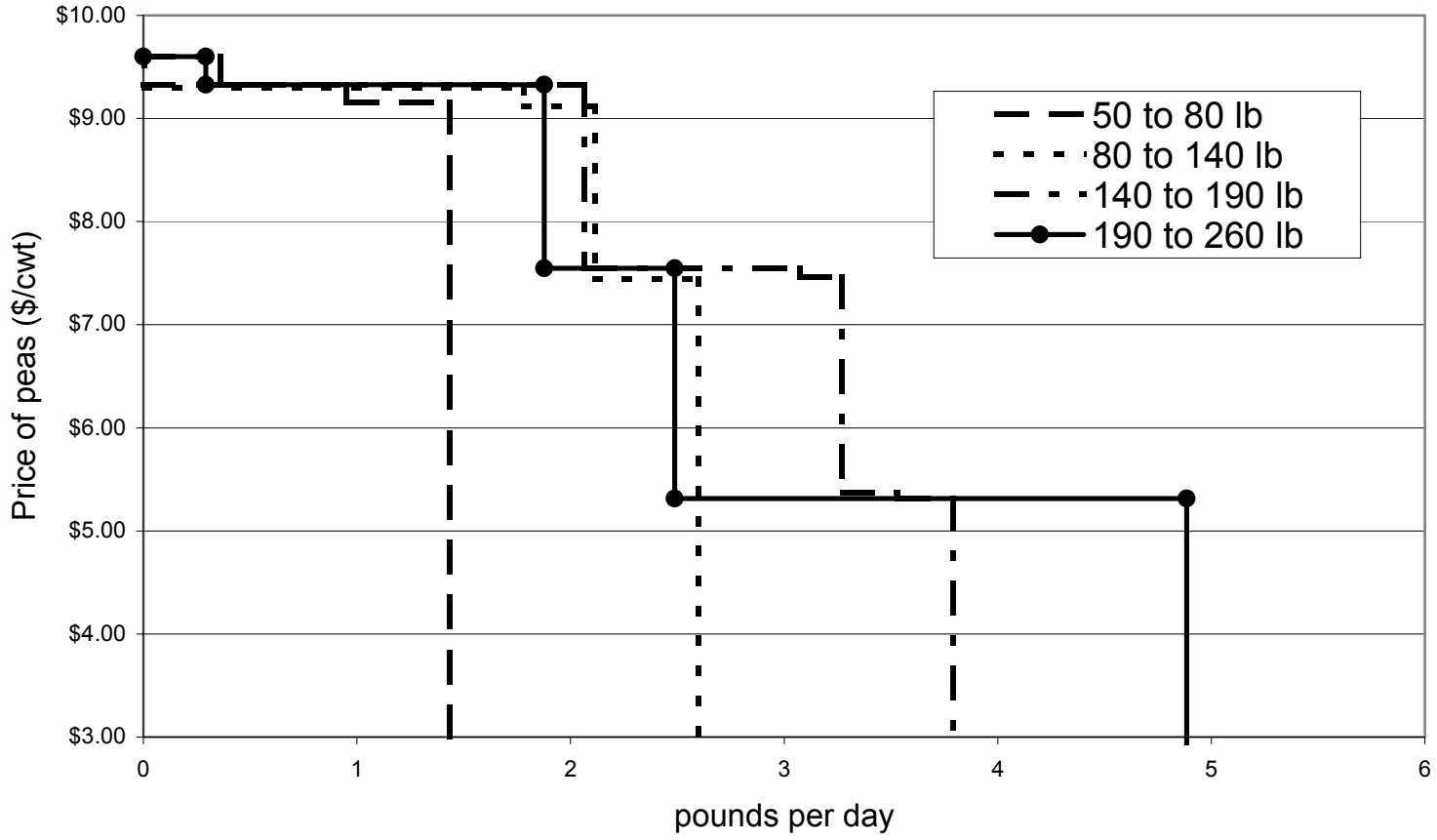
When the prices of corn and barley are increased by one standard deviation (the cost of alternative feeds increases, 47 and 29 cents/lb for corn and barley, respectively), demand for peas shifts upward. In this case, peas are in the optimal solution at prices below $9.81, and 39 percent of the diet consists of peas at prices below $9.63. If the prices of corn and barley are decreased by one standard deviation, peas are not in the least-cost solution at prices at or above $8.86. Peas continue to constitute 39 percent of the diet at prices below $8.68.

Changes in the price of soybean meal have a more important effect on the demand for feed peas. If the price of soybean meal is increased by one standard deviation ($1.97/cwt), peas are in the optimal solution at prices below $10.09 and constitute 39 percent of the diet at prices below $9.20. If the price of soybean meal is decreased one standard deviation, peas are part of the solution at prices below $8.57 and constitute 39 percent of the diet at prices below $8.39.

80 to 140 pound Hogs.

For pigs that are 80 to 140 pounds, using base case prices, peas are part of the least-cost solution at prices below $9.29. Expected daily intake for pigs in this stage is assumed to be 4.99 pounds. With prices between $9.12 and $9.29, the least-cost solution contains 1.78 pounds/day of peas, or 36 percent of the diet. At prices between $7.45 and $9.12, the demand for peas is 2.11 pounds/day, or 42 percent of the diet. The demand for feed peas at prices below $7.45 is 2.6 pounds/day, or about 52 percent of the diet.

Figure 2. Demand for Peas in North Carolina
Average Feedstuff Prices 1994 to 1998



If the prices of corn and barley are increased by one standard deviation, peas become part of the least-cost ration at prices below $10.08 and are a significant part of the diet at prices below $9.80. When the prices of corn and barley are decreased by one standard deviation, peas are no longer part of the optimal solution at prices above $9.11 and are a significant part of the diet at prices below $8.85.

Increasing the price of soybean meal by one standard deviation puts peas in the optimal solution at prices below $10.35, and peas become a significant part of the diet at prices below $10.09. If the price of soybean meal is decreased, peas are no longer part of the least-cost solution at prices above $8.85 and are a significant part of the diet at prices below $8.56.

140 to 190 Pound Hogs

Using base case prices, peas are part of the least-cost solution for 140 to 190 pound hogs at prices below $9.60. The expected daily intake for hogs in this weight class is 6.05 pounds/day. At prices between $9.33 and $9.60, peas constitute a small part of the least-cost diet, 0.36 pounds/day, or 6 percent of the diet. At prices between $7.55 and $9.33, 2.07 pounds/day of peas are part of the optimal solution, which is 34 percent of the diet. From $7.47 to $7.55, the least-cost solution contains 3.07 pounds/day of peas, 51 percent of the diet. With pea prices at $5.37 to $7.47, the least-cost solution contains 3.27 pounds/day of peas, 54 percent of the diet. Between $5.31 and $5.37, the optimal solution contains 3.53 pounds/day of peas, 58 percent of the diet. At prices below $5.31, the demand for peas is 3.79 pounds/day or 63 percent of the diet.

Changing the prices of corn, barley, and soybean meal again changes the demand for peas. When the prices of corn and barley are increased by one standard deviation, peas become part of the optimal solution at prices below $10.08 and are 36 percent or more of the diet at prices below $9.80. Peas are no longer part of the optimal solution at prices above $9.12 when the prices of corn and barley are decreased by one standard deviation. In this scenario, peas account for 36 percent or more of the diet at prices below $8.85.

Peas are part of the optimal solution with prices up to $10.35 when corn and barley prices are not changed and soybean meal prices increase by one standard deviation. They account for 36 percent or more of the diet in this scenario if prices are below $10.09. When the price of soybean meal is decreased by one standard deviation, peas no longer are part of the least-cost solution at prices above $8.85 and are 36 percent or more of the least-cost diet at prices below $8.57.

190 to 260 Pound Hogs

Using base case prices, peas are part of the least-cost diet at prices up to $9.60. Hogs in this weight class are expected to have a daily intake of 6.83 pounds/day. If the price of peas is above $9.33 and below $9.60, the demand for peas in the least-cost solution is 0.29 pounds/day, 4 percent of the diet. At prices between $7.55 and $9.33, the least-cost solution contains 1.88 pounds/day of peas, 27 percent of the diet. When the price of peas is between $5.31 and $7.55,

the least-cost solution contains 2.49 pounds/day of peas, 36 percent of the diet. With prices below $5.31, the optimal solution contains 4.88 pounds/day of peas, 71 percent of the diet.

If the prices of corn and barley are increased by one standard deviation, peas are part of the optimal diet at prices up to $10.08 and are a significant part of the diet at prices up to $9.80. Peas are no longer part of the least-cost ration with prices above $9.11 if the prices of corn and barley are decreased by one standard deviation. In this case, peas are a significant part of the diet at prices up to $8.85.

Increasing the price of soybean meal by one standard deviation puts peas in the least-cost solution at prices up to $10.35 and a significant part of the diet at prices up to $10.09. If the price of soybean meal is decreased by one standard deviation, peas are part of the least-cost diet with prices up to $8.85 and a significant part of the diet with prices below $8.57.

Demand for Feed Peas in Oklahoma

Oklahoma is a feed deficit region that has experienced a dramatic increase in hog production during the past few years. Operations in this state may have good potential for strategic partnerships with pea producers in the Northern Plains. As in North Carolina, operations in Oklahoma, particularly new operations, are generally large. Five-year average prices were used for corn, barley, and soybean meal (44 percent) in Oklahoma for 1994 to 1998. Again, data were sourced from NASS. Table 6 shows the major feed ingredient prices. Table 3 and Figure 3 show demand for peas for use in hog rations in Oklahoma. Detailed results are shown in Appendix B, Tables B.9–B.12. As in the previous section, pea prices are those at which hog rations could bid for peas in the state, in this case in Oklahoma.

Table 6. Prices and Standard Deviations, Oklahoma 1994 to 1998

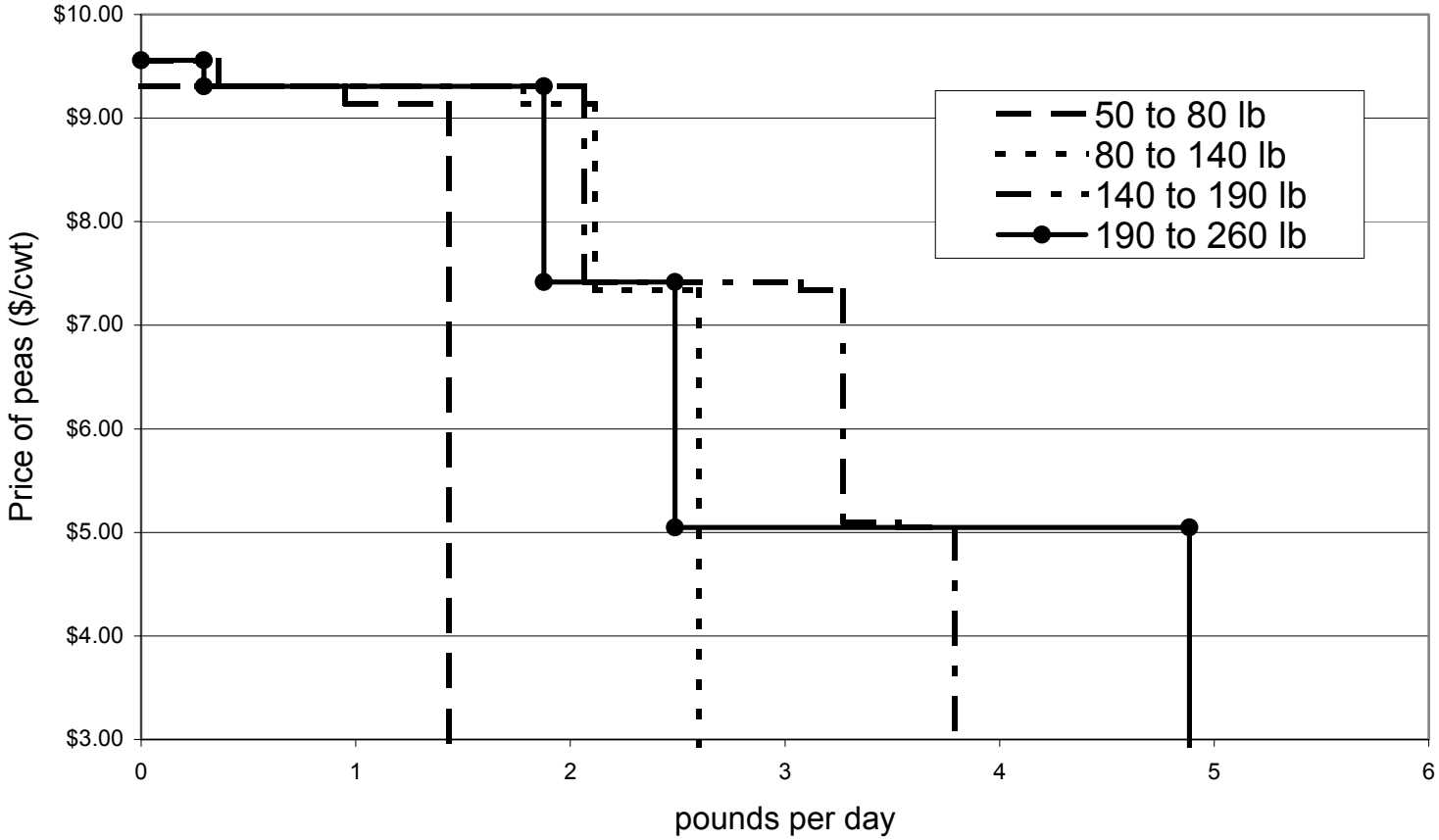
	Five-year average price	Standard deviation
Corn ($/bu)	$2.80	$0.57
Barley ($/bu)	$2.29	$0.53
Soybean Meal ($/cwt)	$16.33	$1.67

50 to 80 pound Hogs

Peas are part of the least-cost solution for 50 to 80 pound pigs at prices below $9.31. At prices between $9.14 and $9.31, the least-cost diet consists of 0.95 pounds/day, or 26 percent of the diet. At prices below $9.14, the least-cost diet consists of 1.44 pounds/day of peas, or 39 percent of the expected daily intake of 3.69 pounds.

If the prices of corn and barley are increased by one standard deviation (57 and 53 cents/bu, respectively), peas are part of the least-cost diet at prices below $9.95 and comprise 39 percent of the diet at prices below $9.78. Peas are not part of the least-cost diet with prices above $8.67 if the prices of corn and barley are decreased by one standard deviation. Increasing the price of soybean meal by one standard deviation ($1.67/cwt) puts peas in the optimal diet with prices below $9.95. If the price of soybean meal is decreased by one standard deviation, peas are in the least-cost diet with prices below $8.66.

Figure 3. Demand for Peas in Oklahoma
Average Feedstuff Prices 1994 to 1998



80 to 140 Pound Hogs

For hogs in the 80 to 140 pound phase, peas are part of the least-cost diet at prices below $9.31. If the price of peas is between $9.14 and $9.31, the least-cost diet consists of 1.78 pounds/day of peas, 36 percent of the diet. With prices between $7.34 and $9.14, the least-cost diet consists of 2.11 pounds/day of peas, 42 percent of the diet. At prices below $7.34, the least-cost diet consists of 2.6 pounds/day, or 52 percent of the expected daily intake of 4.99 pounds.

When the prices of corn and barley are increased by one standard deviation, peas are a significant part of the least-cost diet at prices below $9.49. Peas are no longer a significant part of the diet at prices above $8.67 if the prices of corn and barley are decreased by one standard deviation. Peas are a significant part of the least-cost diet at prices below $9.95 when the price of soybean meal is increased by one standard deviation and at prices below $8.66 when the price of soybean meal is decreased by one standard deviation, respectively.

140 to 190 Pound Hogs

For hogs in the 140 to 190 pound class, peas are part of the least-cost diet at prices below $9.56. At prices between $9.31 and $9.56, peas consume a small part of the least-cost diet, 0.36 pounds/day, or 6 percent of the diet. At prices above $7.42 and below $9.31, 2.07 pounds/day of peas are part of the optimal solution, which is 34 percent of the diet. If pea prices are between $7.34 and $7.42, the least-cost solution contains 3.07 pounds/day, 51 percent of the diet. With prices from $5.10 to $7.34, the least-cost solution contains 3.27 pounds/day of peas, 54 percent of the diet. At prices between $5.05 and $5.10, the optimal solution contains 3.53 pounds/day of peas, 58 percent of the diet. At prices below $5.05, the least-cost diet consists of 3.79 pounds of peas per day, or about 63 percent of the expected daily intake of 6.05 pounds.

When the prices of corn and barley are increased, peas enter the least-cost diet at prices below $10.20 and are 36 percent or more of the diet at prices below $9.95. Peas are no longer part of the optimal solution at prices above $8.91 when the prices of corn and barley are decreased by one standard deviation. In this scenario, peas are 36 percent or more of the diet at prices below $8.66.

Peas are part of the optimal solution with prices up to $10.19 when corn and barley prices are not changed and soybean meal prices are increased by one standard deviation. They constitute 36 percent or more of the diet in this scenario if prices are below $9.95. When the price of soybean meal is decreased by one standard deviation, peas no longer are part of the least-cost solution at prices above $8.92 and are 36 percent or more of the least-cost diet at prices below $8.66.

190 to 260 Pound Hogs

Using base case prices, peas are part of the least-cost diet at prices up to $9.56. If the price of peas is above $9.31 and below $9.56, the demand for peas in the least-cost solution is 0.29 pounds/day, 4 percent of the diet. At prices between $7.42 and $9.31, the least-cost solution contains 1.88 pounds/day of peas, 27 percent of the diet. When the price of peas is between

$5.05 and $7.42, the least-cost solution contains 2.49 pounds/day of peas, 36 percent of the diet. At prices below $5.05, the optimal solution contains 4.88 pounds/day of peas, 71 percent of the expected daily intake of 6.83 pounds/day.

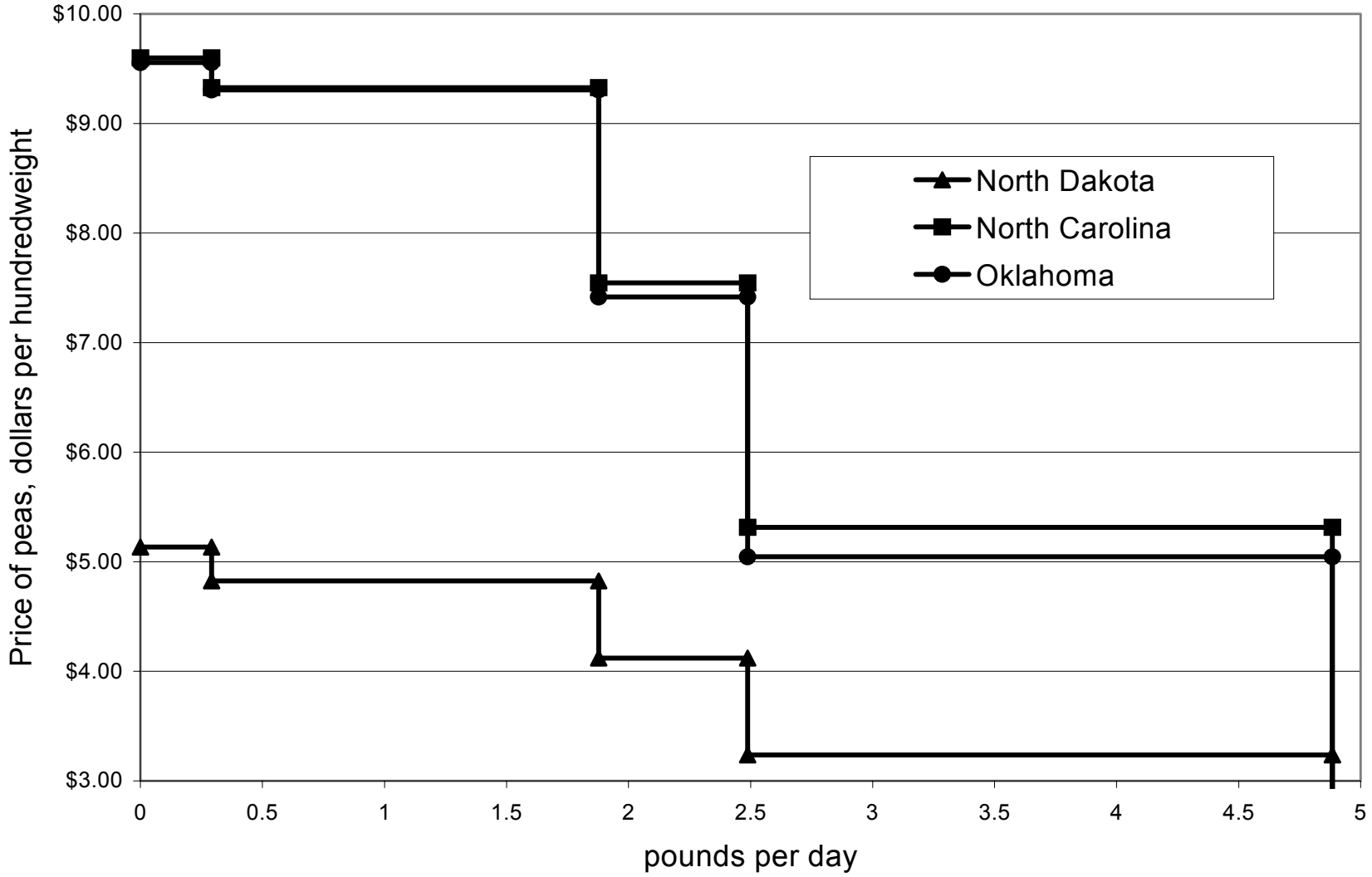
If the prices of corn and barley are increased by one standard deviation, peas are part of the optimal diet at prices up to $10.50 and are a significant part of the diet at prices up to $9.23. Peas are no longer part of the least-cost diet at prices above $8.92 if the prices of corn and barley are decreased by one standard deviation. In this case, peas are a significant part of the diet at prices up to $8.67. Increasing the price of soybean meal puts peas in the least-cost solution at prices up to $10.19 and they become a significant part of the diet at prices up to $9.95. If the price of soybean meal is decreased by one standard deviation, peas are part of the least-cost diet with prices up to $8.92 and become a significant part of the diet with prices below $8.66.

IMPLICATIONS

The results of the LP analysis suggest that peas are an attractive alternative as a feed ingredient in hog diets, especially in feed deficit regions (Figure 4). Peas can be part of the least-cost diet replacing corn, barley, and soybean meal. Except at high prices or under low-cost periods for alternative feedstuffs, peas can constitute up to 39 percent of the diet for pigs in the 50 to 80 pound weight category. When 39 percent of the diet for pigs in this weight class consists of peas, methionine is added as a supplement. Previous studies have suggested a limit to how much of the ration can be comprised of peas, in large part due to the relatively low level of methionine in peas. The model employed to calculate least-cost rations supplements for the low levels of methionine by adding a methionine supplement. There are no anti-nutritional factors that would make it necessary to limit the amount of peas that are fed. The only factors that would limit the use of peas are cost and the nutritional constraints included in the LP problem. For the 50 to 80 pound pigs, no more than 39 percent of the diet consisted of peas, regardless of how low the price of peas may be.

For hogs 80 to 140 pounds, peas account for up to 52 percent of the diet if prices are low enough. Peas can constitute 36 to 42 percent of the diet for hogs in this class. It is possible for peas to account for 63 percent of a least-cost diet for hogs 140 to 190 pounds, but this would require lower than average prices received in recent years in North Dakota. With reasonable prices, though, peas could account for up to 54 percent of the least-cost diet for hogs in this phase. With very low prices, it is possible for the least-cost diet for 190 to 260 pound hogs to consist of 71 percent peas. Even with this high inclusion rate, methionine is not added because the larger hogs have lower requirements for amino acids. The high lysine content of peas, though, is beneficial. When the price of peas is too high for it to be included in the diet, it is necessary for lysine to be added as a supplement. Peas could constitute, with average prices, 27 to 36 percent of the diet for hogs in the 190 to 260 pound growth stage.

Figure 4. Demand for Peas for 190-260 lb Hogs



Data for feed pea prices in North Dakota in 1998, 1999, and the first three months of 2000 were obtained from issues of *Agweek*. The average feed pea price in Valley City, North Dakota during this time period was $3.50 per cwt. Prices for corn and barley in North Dakota have been low during this period, as have prices for peas. The LP problems for North Dakota were estimated using corn, barley, and soybean meal price data for 1998-1999. Comparably, the ten-year average price for feed peas in North Dakota for 1986 to 1995 was $5.88 per cwt.

If a price of $3.50 per cwt is assumed for peas, the least-cost diet would consist of 39 percent peas for 50 to 80 pound hogs, even if the prices of other feedstuffs varied by as much as one standard deviation in either direction. In the diet for 80 to 140 pound hogs, 52 percent would consist of peas, regardless of one standard deviation change in the prices of the other feedstuffs. For 140 to 190 pound hogs, 54 percent of the diet would consist of peas using the base case (two- or five-year average) prices for corn, barley, and soybean meal. Changing the price of soybean meal would not affect this solution and decreasing the prices of corn and soybean meal would still result in a 54 percent inclusion rate, but a one standard deviation increase in corn and barley prices would result in 63 percent of the diet consisting of peas. Using base case prices for the other feed ingredients, 36 percent of the diet for hogs 190 to 260 pounds would consist of peas. If the prices of corn and barley, however, increased by one standard deviation and all other prices remained the same, the least-cost ration would consist of 71 percent peas.

Decomposition of Feed Pea Value

The shadow prices of the binding constraints in the LP problem along with the composition of the pea indicate which characteristics of the pea give it value. For 50 to 80 pound pigs in North Dakota, the constraints for minimum digestible energy, crude protein, calcium, phosphorous, and methionine are binding. Digestible energy and crude protein, in particular, and also calcium, phosphorous, and methionine are, therefore, the characteristics that give the pea value in this diet. Increasing the content of any of these characteristics in the pea would increase its value. Peas are high in lysine compared to corn and barley, which makes it attractive to substitute for these feedstuffs, in particular corn. Lysine, though, is not a binding constraint in this diet. Increasing the lysine content of peas would not increase their value.

In the diet for 80 to 140 pound hogs, the value comes from the digestible energy, calcium, methionine, and tryptophan. These are the constraints that are binding. In this case, tryptophan and digestible energy provide the most value. The minimum constraints for digestible energy, calcium, methionine, and tryptophan are again binding in the diet for 140 to 190 pound hogs, along with the minimum constraint for phosphorous. These attributes give the pea value for feeding hogs in the 140 to 190 pound growth phase. Digestible energy, calcium, phosphorous, and tryptophan are the qualities that give peas value as a feed ingredient for 190 to 260 pound hogs.

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APPENDIX A: CURRENT PERIOD ANALYSIS FOR INDIVIDUAL WEIGHT CLASS

At the explicit request of agencies providing partial support for this research in an initial phase of their market development strategies, value of field peas was calculated using prices in early 2000. Demand is specified for each location and each stage of growth although only that for hogs in the 190 to 260 pound growth stage is reported. The demand schedules are to be interpreted as the number of pounds of peas in a daily least-cost ration for pigs in the 190 to 260 pound stage of growth at each price. Prices are expressed in dollars per ton. The feed pea price is to be interpreted at that location. The cost of alternative feedstuffs used was the price in February, 2000. These values are shown in Table A.1. Common prices were used for supplementary feed ingredients regardless of location. These values are shown in Table A.2. Prices of feed grains and soybean meal (alternative feedstuffs available to the ration) were unusually low during early 2000 and, therefore, these feedstuffs are more attractive as low-cost feed alternatives. As such, at every location and for hogs in every growth stage, the price the ration would pay for field peas is lower than that found when intermediate or long-run historic average prices for alternative feedstuffs are used. Extreme caution is, therefore,` recommended in interpreting the results. The value of field peas in swine rations will increase with the price of alternative feedstuffs. This appendix is included to demonstrate the effect of using current, rather than expected, prices for alternative feedstuffs.

Table A.1. Feed Prices, February 2000

Location	Portland, OR	Salt Lake City, UT	Raleigh, NC	North Dakota
Feed Barley ($ per bu)	2.35	1.67	1.50	1.40
Corn ($ per bu)	2.75	1.54	2.20	1.60
Soybean Meal ($ per ton)	174	174	167	170

Table A.2. Ingredients and Prices

Dicalcium Phosphate	$395/ton
Limestone	$80/ton
Lysine	$1.01/lb
DL-methionine	$1.31/lb
Threonine	$1.55/lb
Tryptophan	$201/lb
Salt	$80/ton
Vitamin Premix	$3,000/ton
Trace Minerals	$1,700/ton
Selenium Premix	$1,000/ton

Value of Field Peas

Important in assessing a potential market for peas are their value in hog rations (influenced both by the nutrient needs of the pig and cost of alternative feedstuffs), transportation cost from the point of production to hog production site(s) under consideration, and any other factors that influence the operation's ability and willingness to use peas in the ration. The value of field peas for hogs in the 190 to 260 pound growth stage is, in general, greater than the value for hogs in any other stage. The value of field peas in a swine ration does not differ substantially

when metabolizable versus digestible energy is used in balancing swine nutrient requirements with nutrients provided by feedstuffs. However, in general, the maximum amount of field peas included in the ration (at very low prices) is lower when metabolizable energy is used. Demand for field peas (quantity demanded at various prices) is revealed for each of four locations for hogs in the 190 to 260 pound growth stage. Locations include Portland, OR; Salt Lake City, UT; Raleigh, NC; and Minot, ND.

Portland, Oregon. The location of Portland, OR represents potential markets to the west of North Dakota and to the Southwest of Canadian Prairie Provinces. The specific location of Portland was chosen due to the availability of nonaggregate (daily) price data. Pea prices shown on each demand schedule are the prices hog rations could bid per ton for peas in Portland. Prices then must be adjusted by transportation cost to develop a bid price in the source location (in this report, Winnipeg, MB is used as the source location). In 2000, the transportation cost from Winnipeg, MB to Portland, OR was approximately $45 per ton. However, transportation costs vary considerably depending on transportation mode (rail, truck, or rail/truck combination), distance hauled, load size and weight, and location (because of, for example, the importance of the availability of back hauls).

Using digestible energy, peas are part of the least-cost diet at prices up to $130 per ton (or $85 per ton after transportation cost from Winnipeg) with prices for barley, corn, and soybean meal as indicated in Table A.1. Hogs in this weight class are expected to have a daily intake of 6.83 pounds/day. With prices below $100, the least-cost solution contains 4.88 pounds/day of peas, 72 percent of the diet. When the price reaches $100, the least-cost solution drops to one containing 2.67 pounds/day of peas, 39 percent of the diet. At prices between $100 and $113, the least-cost solution contains 2.49 pounds/day of peas, 36 percent of the diet. At prices between $113 and $123, the least-cost solution contains 1.86 pounds/day of peas, 27 percent of the diet. If the price of peas is above $123 and below $130, the demand for peas in the least-cost solution is 0.61 pounds/day, 9 percent of the diet.

Using metabolizable energy, the value of field peas in the ration is lower. At the price of $99 per ton, peas comprise 44 percent of a least-cost ration at 2.98 pounds/day.

Salt Lake City, Utah. Utah is a feed deficit region that has experienced a dramatic increase in hog production during the past few years. Operations in this state may have good potential for strategic partnerships with North Dakota and Canadian pea producers. As in North Carolina, operations in, and in states surrounding, Utah, particularly new operations, are generally large. Pea prices on the demand schedules are the prices hog rations could bid for peas in Salt Lake City, UT. Prices then must be adjusted by transportation cost to develop a bid price in the source location (in this report, Winnipeg, MB is used as the source location). In 2000, the transportation cost from Winnipeg, MB to Salt Lake City, UT was approximately $46 per ton.

Using digestible energy, for pigs in the 190 to 260 pound growth stage, field peas are part of the least-cost diets in Salt Lake City at prices up to $120 per ton ($74 per ton in Winnipeg). At prices below $63, the optimal solution contains 5.02 pounds/day of peas, 73 percent of the expected daily intake of 6.83 pounds/day. When the price of peas is between $63 and $87, the least-cost solution contains 4.88 pounds/day of peas, 72 percent of the diet. At prices between $87 and $102, the least-cost solution contains 2.49 pounds/day of peas, 36 percent of the diet. If

the price of peas is above $102 and below $113, the demand for peas in the least-cost solution is 1.86 pounds/day, 27 percent of the diet. At prices between $113 and $120, the least-cost solution contains .61 pounds of peas per day or 9 percent of the diet.

Using metabolizable energy, the value of field peas in the ration is lower. At the price of $85 per ton, peas comprise 44 percent of a least-cost ration at 2.98 pounds/day.

North Carolina. North Carolina hog inventory was 9.4 million on March 1, 2000. The state had over 16 percent of U.S. hog inventory and is a major feed-deficit region. It is a market where field peas from the Northern Plains and Canada may be an attractive feed alternative. The large operations in this state may make it a good location in which to identify strategic partners for marketing large quantities of feed peas. Pea prices shown on each demand schedule are the prices hog rations could bid for peas in Raleigh, NC. Prices then must be adjusted by transportation cost to develop a bid price in the source location (in this report, Winnipeg, MB is used as the source location). The transportation cost from Winnipeg, MB to Chicago (to which the BNSF railroad runs) is $31 per ton. Even the expense of moving the peas to Chicago, under the use of current prices for alternative feeds (e.g., corn), makes the North Carolina market uncompetitive.

Using digestible energy, peas are part of the least-cost diet at prices up to $109 per ton. Hogs in this weight class are expected to have a daily intake of 6.83 pounds/day. With prices below $55, the optimal solution contains 5.02 pounds/day of peas, 73 percent of the diet. When the price of peas is between $55 and $78, the least-cost solution contains 4.88 pounds/day of peas, 72 percent of the diet. At prices between $78 and $92, the least-cost solution contains 2.49 pounds/day of peas, 36 percent of the diet. At prices between $92 and $102, the least-cost solution contains 1.86 pounds/day of peas, 27 percent of the diet. If the price of peas is above $102 and below $109, the demand for peas in the least-cost solution is 0.61 pounds/day, 9 percent of the diet.

Using metabolizable energy, the value of field peas in the ration is lower. At a price of $74 per ton, peas comprise 44 percent of a least-cost ration at 2.98 pounds/day.

North Dakota. North Dakota is a feed surplus region. It is not a major producer of hogs but is a major producer of barley. Pea prices shown on each demand schedule are the prices hog rations could bid for peas in North Dakota. Prices then must be adjusted by transportation cost to develop a bid price in the source location (in this report, Winnipeg, MB is used as the source location). In 2000, the transportation cost from Winnipeg, MB to Minot, ND was approximately $20 per ton.

Using digestible energy, peas are part of the least-cost diet at prices up to $102 per ton ($82 per ton in Winnipeg). Hogs in this weight class are expected to have a daily intake of 6.83 pounds/day. With prices below $26, the optimal solution contains 5.02 pounds/day of peas, 73 percent of the diet. When the price of peas is between $26 and $59, the least-cost solution contains 4.88 pounds/day of peas, 72 percent of the diet. At prices between $59 and $79, the least-cost solution contains 2.49 pounds/day of peas, 36 percent of the diet. At prices between $79 and $94, the least-cost solution contains 1.86 pounds/day of peas, 27 percent of the diet. If

the price of peas is above $94 and below $102, the demand for peas in the least-cost solution is 0.61 pounds/day, 9 percent of the diet.

Using metabolizable energy, the value of field peas in the ration is lower. At a price of $59 per ton, peas comprise 44 percent of a least-cost ration at 2.98 pounds/day.

Implications

The results of the LP analysis suggest that peas are an attractive alternative as a feed ingredient in hog diets at relatively low prices when the price of alternative feedstuffs are unusually low. It is only at low prices that field peas can be part of the least-cost diet replacing corn, barley, and soybean meal when, as was the case during February 2000, prices of these feedstuffs are low. Except at higher prices, peas can easily constitute up to 39 percent of the diet for pigs in lighter growth stages (e.g., 50 to 80 pounds). When, for example, 39 percent of the diet for pigs in this weight class consists of peas, methionine is added as a supplement. Previous studies have suggested a limit to how much of the ration can be comprised of peas, in large part due to the relatively low level of methionine in peas. The model employed to calculate least-cost rations supplements for the low levels of methionine by adding a methionine supplement. There are no anti-nutritional factors that would make it necessary to limit the amount of peas that are fed. The only factors that would limit the use of peas are cost and the nutritional constraints included in the LP problem. With very low prices, it is possible for the least-cost diet for 190 to 260 pound hogs to consist of 73 percent peas. Even with this high inclusion rate, methionine is not added because the larger hogs have lower requirements for amino acids. The high lysine content of peas, though, is still beneficial. When the price of peas is too high for it to be included in the diet, it is necessary for lysine to be added as a supplement. Peas could constitute, with average prices, 27 to 36 percent of the diet for hogs in the 190 to 260 pound growth stage.

APPENDIX B: LEAST-COST RATION RESULTS

The following tables show detailed results from the LP model discussed in the results section of this paper. Tables B.2, B.5, and B.6 show the base-case prices used and the standard deviations for feed barley, corn, and soybean meal (sbm). The tables show a price range for peas and a least-cost ration solution that meets all the nutrition requirements for each price range.

Table B.1. Least-cost ration solution for 50-80 pound hogs in North Dakota

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 4.647	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 4.647	$ 4.821	0.95	0.09	1.86	0.70	0.032	0.0319	
$ 4.821		0	0.26	2.28	1.07	0.0294	0.0325	

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 4.881	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 4.881	$ 5.056	0.95	0.09	1.86	0.70	0.032	0.0319	
$ 5.056		0	0.26	2.28	1.07	0.0294	0.0325	

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 4.420	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 4.420	$ 4.593	0.95	0.09	1.86	0.70	0.032	0.0319	
$ 4.593		0	0.26	2.28	1.07	0.0294	0.0325	

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 5.048	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 5.048	$ 5.222	0.95	0.09	1.86	0.70	0.032	0.0319	
$ 5.222		0	0.26	2.28	1.07	0.0294	0.0325	

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 4.252	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 4.252	$ 4.428	0.95	0.09	1.86	0.70	0.032	0.0319	
$ 4.428		0	0.26	2.28	1.07	0.0294	0.0325	

Table B.2. Least-cost ration solution for 80-140 pound hogs in North Dakota

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 4.044	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	
$ 4.044	$ 4.650	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	
$ 4.650	$ 4.825	1.78	0.14	2.51	0.45	0.0336	0.042		
$ 4.825	$ 5.135	0.004	0.46	3.29	1.14	0.0289	0.0433		
$ 5.135		0	0.46	3.29	1.14	0.0289	0.0433		0.000013

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 4.346	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	
$ 4.346	$ 4.881	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	
$ 4.881	$ 5.056	1.78	0.14	2.51	0.45	0.0336	0.042		
$ 5.056	$ 5.371	0.004	0.46	3.29	1.14	0.0289	0.0433		
$ 5.371		0	0.46	3.29	1.14	0.0289	0.0433		0.000013

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 3.742	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	
$ 3.742	$ 4.420	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	
$ 4.420	$ 4.593	1.78	0.14	2.51	0.45	0.0336	0.042		
$ 4.593	$ 4.898	0.004	0.46	3.29	1.14	0.0289	0.0433		
$ 4.898		0	0.46	3.29	1.14	0.0289	0.0433		0.000013

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 4.264	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	
$ 4.264	$ 5.048	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	
$ 5.048	$ 5.222	1.78	0.14	2.51	0.45	0.0336	0.042		
$ 5.222	$ 5.524	0.004	0.46	3.29	1.14	0.0289	0.0433		
$ 5.524		0	0.46	3.29	1.14	0.0289	0.0433		0.000013

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 3.894	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	
$ 3.894	$ 4.252	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	
$ 4.252	$ 4.428	1.78	0.14	2.51	0.45	0.0336	0.042		
$ 4.428	$ 4.709	0.004	0.46	3.29	1.14	0.0289	0.0433		
$ 4.709		0	0.46	3.29	1.14	0.0289	0.0433		0.000013

Table B.3. Least-cost ration solution for 140-190 pound hogs in North Dakota

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 3.237	3.79	0	2.14	0	0.0291	0.0498		
$ 3.237	$ 3.293	3.53	0.04	2.36	0	0.0305	0.0497		
$ 3.293	$ 4.044	3.27	0.08	2.58	0	0.032	0.0495	0.00011	
$ 4.044	$ 4.120	3.07	0.11	2.70	0.04	0.0321	0.0495		
$ 4.120	$ 4.825	2.07	0.28	3.32	0.26	0.0331	0.0496		
$ 4.825	$ 5.135	0.36	0.58	4.07	0.92	0.0286	0.0508		
$ 5.135		0	0.63	4.24	1.06	0.0277	0.0511		0.001214

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 3.628	3.79	0	2.14	0	0.0291	0.0498		
$ 3.628	$ 3.683	3.53	0.04	2.36	0	0.0305	0.0497		
$ 3.683	$ 4.346	3.27	0.08	2.58	0	0.032	0.0495	0.00011	
$ 4.346	$ 4.422	3.07	0.11	2.70	0.04	0.0321	0.0495		
$ 4.422	$ 5.056	2.07	0.28	3.32	0.26	0.0331	0.0496		
$ 5.056	$ 5.371	0.36	0.58	4.07	0.92	0.0286	0.0508		
$ 5.371		0	0.63	4.24	1.06	0.0277	0.0511		0.001214

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 2.847	3.79	0	2.14	0	0.0291	0.0498		
$ 2.847	$ 2.902	3.53	0.04	2.36	0	0.0305	0.0497		
$ 2.902	$ 3.742	3.27	0.08	2.58	0	0.032	0.0495	0.00011	
$ 3.742	$ 3.818	3.07	0.11	2.70	0.04	0.0321	0.0495		
$ 3.818	$ 4.593	2.07	0.28	3.32	0.26	0.0331	0.0496		
$ 4.593	$ 4.898	0.36	0.58	4.07	0.92	0.0286	0.0508		
$ 4.898		0	0.63	4.24	1.06	0.0277	0.0511		0.001214

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 3.237	3.79	0	2.14	0	0.0291	0.0498		
$ 3.237	$ 3.293	3.53	0.04	2.36	0	0.0305	0.0497		
$ 3.293	$ 4.264	3.27	0.08	2.58	0	0.032	0.0495	0.00011	
$ 4.264	$ 4.341	3.07	0.11	2.70	0.04	0.0321	0.0495		
$ 4.341	$ 5.222	2.07	0.28	3.32	0.26	0.0331	0.0496		
$ 5.222	$ 5.524	0.36	0.58	4.07	0.92	0.0286	0.0508		
$ 5.524		0	0.63	4.24	1.06	0.0277	0.0511		0.001214

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 3.237	3.79	0	2.14	0	0.0291	0.0498		
$ 3.237	$ 3.293	3.53	0.04	2.36	0	0.0305	0.0497		
$ 3.293	$ 3.824	3.27	0.08	2.58	0	0.032	0.0495	0.00011	
$ 3.824	$ 3.899	3.07	0.11	2.70	0.04	0.0321	0.0495		
$ 3.899	$ 4.428	2.07	0.28	3.32	0.26	0.0331	0.0496		
$ 4.428	$ 4.709	0.36	0.58	4.07	0.92	0.0286	0.0508		
$ 4.709		0	0.63	4.24	1.06	0.0277	0.0511		0.001214

Table B.4. Least-cost ration solution for 190-260 pound hogs in North Dakota

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 3.237	4.88	0	1.83	0	0.0175	0.0561	0
$ 3.237	$ 4.120	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 4.120	$ 4.825	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 4.825	$ 5.135	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 5.135		0.0	0.79	5.05	0.86	0.0264	0.0558	0.000983

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 3.628	4.88	0	1.83	0	0.0175	0.0561	0
$ 3.628	$ 4.422	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 4.422	$ 5.056	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 5.056	$ 5.371	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 5.371		0.0	0.79	5.05	0.86	0.0264	0.0558	0.000983

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 2.847	4.88	0	1.83	0	0.0175	0.0561	0
$ 2.847	$ 3.818	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 3.818	$ 4.593	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 4.593	$ 4.898	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 4.898		0.0	0.79	5.05	0.86	0.0264	0.0558	0.000983

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 3.237	4.88	0	1.83	0	0.0175	0.0561	0
$ 3.237	$ 4.341	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 4.341	$ 5.222	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 5.222	$ 5.524	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 5.524		0.0	0.79	5.05	0.86	0.0264	0.0558	0.000983

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 3.237	4.88	0	1.83	0	0.0175	0.0561	0
$ 3.237	$ 3.899	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 3.899	$ 4.428	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 4.428	$ 4.709	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 4.709		0.0	0.79	5.05	0.86	0.0264	0.0558	0.000983

Table B.5. Least-cost ration solution for 50-80 pound hogs in North Carolina

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 9.155	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 9.155	$ 9.328	0.95	0.09	1.86	0.70	0.032	0.0319	0
$ 9.328		0	0.26	2.28	1.07	0.0294	0.0325	0

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 9.628	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 9.628	$ 9.803	0.95	0.09	1.86	0.70	0.032	0.0319	0
$ 9.803		0	0.26	2.28	1.07	0.0294	0.0325	0

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 8.682	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 8.682	$ 8.854	0.95	0.09	1.86	0.70	0.032	0.0319	0
$ 8.854		0	0.26	2.28	1.07	0.0294	0.0325	0

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 9.919	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 9.919	$ 10.091	0.95	0.09	1.86	0.70	0.032	0.0319	0
$ 10.091		0	0.26	2.28	1.07	0.0294	0.0325	0

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 8.391	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 8.391	$ 8.565	0.95	0.09	1.86	0.70	0.032	0.0319	0
$ 8.565		0	0.26	2.28	1.07	0.0294	0.0325	0

Table B.6. Least-cost ration solution for 80-140 pound hogs in North Carolina

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 7.446	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	0
$ 7.446	$ 9.120	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	0
$ 9.120	$ 9.293	1.78	0.14	2.51	0.45	0.0336	0.042	0	0
$ 9.293	$ 9.565	0.004	0.46	3.29	1.14	0.0289	0.0433	0	0
$ 9.565		0	0.46	3.29	1.14	0.0289	0.0433	0	0.000013

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 8.084	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	0
$ 8.084	$ 9.628	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	0
$ 9.628	$ 9.803	1.78	0.14	2.51	0.45	0.0336	0.042	0	0
$ 9.803	$ 10.083	0.004	0.46	3.29	1.14	0.0289	0.0433	0	0
$ 10.083		0	0.46	3.29	1.14	0.0289	0.0433	0	0.000013

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 6.847	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	0
$ 6.847	$ 8.682	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	0
$ 8.682	$ 8.854	1.78	0.14	2.51	0.45	0.0336	0.042	0	0
$ 8.854	$ 9.115	0.004	0.46	3.29	1.14	0.0289	0.0433	0	0
$ 9.115		0	0.46	3.29	1.14	0.0289	0.0433	0	0.000013

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 7.888	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	0
$ 7.888	$ 9.919	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	0
$ 9.919	$ 10.091	1.78	0.14	2.51	0.45	0.0336	0.042	0	0
$ 10.091	$ 10.347	0.004	0.46	3.29	1.14	0.0289	0.0433	0	0
$ 10.347		0	0.46	3.29	1.14	0.0289	0.0433	0	0.000013

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 7.042	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	0
$ 7.042	$ 8.391	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	0
$ 8.391	$ 8.565	1.78	0.14	2.51	0.45	0.0336	0.042	0	0
$ 8.565	$ 8.851	0.004	0.46	3.29	1.14	0.0289	0.0433	0	0
$ 8.851		0	0.46	3.29	1.14	0.0289	0.0433	0	0.000013

Table B.7. Least-cost ration solution for 140-190 pound hogs in North Carolina

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 5.314	3.79	0	2.14	0	0.0291	0.0498	0	0
$ 5.314	$ 5.370	3.53	0.04	2.36	0	0.0305	0.0497	0	0
$ 5.370	$ 7.465	3.27	0.08	2.58	0	0.032	0.0495	0.0001105	0
$ 7.465	$ 7.546	3.07	0.11	2.70	0.04	0.0321	0.0495	0	0
$ 7.546	$ 9.328	2.07	0.28	3.32	0.26	0.0331	0.0496	0	0
$ 9.328	$ 9.599	0.36	0.58	4.07	0.92	0.0286	0.0508	0	0
$ 9.599		0	0.63	4.24	1.06	0.0277	0.0511	0	0.0012136

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 6.113	3.79	0	2.14	0	0.0291	0.0498	0	0
$ 6.113	$ 6.169	3.53	0.04	2.36	0	0.0305	0.0497	0	0
$ 6.169	$ 8.084	3.27	0.08	2.58	0	0.032	0.0495	0.0001105	0
$ 8.084	$ 8.165	3.07	0.11	2.70	0.04	0.0321	0.0495	0	0
$ 8.165	$ 9.803	2.07	0.28	3.32	0.26	0.0331	0.0496	0	0
$ 9.803	$ 10.083	0.36	0.58	4.07	0.92	0.0286	0.0508	0	0
$ 10.083		0	0.63	4.24	1.06	0.0277	0.0511	0	0.0012136

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 4.515	3.79	0	2.14	0	0.0291	0.0498	0	0
$ 4.515	$ 4.570	3.53	0.04	2.36	0	0.0305	0.0497	0	0
$ 4.570	$ 6.847	3.27	0.08	2.58	0	0.032	0.0495	0.0001105	0
$ 6.847	$ 6.928	3.07	0.11	2.70	0.04	0.0321	0.0495	0	0
$ 6.928	$ 8.854	2.07	0.28	3.32	0.26	0.0331	0.0496	0	0
$ 8.854	$ 9.115	0.36	0.58	4.07	0.92	0.0286	0.0508	0	0
$ 9.115		0	0.63	4.24	1.06	0.0277	0.0511	0	0.0012136

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 5.314	3.79	0	2.14	0	0.0291	0.0498	0	0
$ 5.314	$ 5.370	3.53	0.04	2.36	0	0.0305	0.0497	0	0
$ 5.370	$ 7.888	3.27	0.08	2.58	0	0.032	0.0495	0.0001105	0
$ 7.888	$ 7.970	3.07	0.11	2.70	0.04	0.0321	0.0495	0	0
$ 7.970	$ 10.091	2.07	0.28	3.32	0.26	0.0331	0.0496	0	0
$ 10.091	$ 10.347	0.36	0.58	4.07	0.92	0.0286	0.0508	0	0
$ 10.347		0	0.63	4.24	1.06	0.0277	0.0511	0	0.0012136

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 5.314	3.79	0	2.14	0	0.0291	0.0498	0	0
$ 5.314	$ 5.370	3.53	0.04	2.36	0	0.0305	0.0497	0	0
$ 5.370	$ 7.042	3.27	0.08	2.58	0	0.032	0.0495	0.0001105	0
$ 7.042	$ 7.122	3.07	0.11	2.70	0.04	0.0321	0.0495	0	0
$ 7.122	$ 8.565	2.07	0.28	3.32	0.26	0.0331	0.0496	0	0
$ 8.565	$ 8.851	0.36	0.58	4.07	0.92	0.0286	0.0508	0	0
$ 8.851		0	0.63	4.24	1.06	0.0277	0.0511	0	0.0012136

Table B.8. Least-cost ration solution for 190-260 pound hogs in North Carolina

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 5.314	4.88	0	1.83	0	0.0175	0.0561	0
$ 5.314	$ 7.546	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 7.546	$ 9.328	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 9.328	$ 9.599	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 9.599		0	0.79	5.05	0.86	0.0264	0.0558	0.00098

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 6.113	4.88	0	1.83	0	0.0175	0.0561	0
$ 6.113	$ 8.165	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 8.165	$ 9.803	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 9.803	$ 10.083	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 10.083		0	0.79	5.05	0.86	0.0264	0.0558	0.00098

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 4.515	4.88	0	1.83	0	0.0175	0.0561	0
$ 4.515	$ 6.928	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 6.928	$ 8.854	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 8.854	$ 9.115	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 9.115		0	0.79	5.05	0.86	0.0264	0.0558	0.00098

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 5.314	4.88	0	1.83	0	0.0175	0.0561	0
$ 5.314	$ 7.970	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 7.970	$ 10.091	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 10.091	$ 10.347	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 10.347		0	0.79	5.05	0.86	0.0264	0.0558	0.00098

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 5.314	4.88	0	1.83	0	0.0175	0.0561	0
$ 5.314	$ 7.122	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 7.122	$ 8.565	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 8.565	$ 8.851	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 8.851		0	0.79	5.05	0.86	0.0264	0.0558	0.00098

Table B.9. Least-cost ration solution for 50-80 pound hogs in Oklahoma

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 9.141	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 9.141	$ 9.307	0.95	0.09	1.86	0.70	0.032	0.0319	0
$ 9.307		0	0.26	2.28	1.07	0.0294	0.0325	0

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 9.784	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 9.784	$ 9.948	0.95	0.09	1.86	0.70	0.032	0.0319	0
$ 9.948		0	0.26	2.28	1.07	0.0294	0.0325	0

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 8.499	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 8.499	$ 8.666	0.95	0.09	1.86	0.70	0.032	0.0319	0
$ 8.666		0	0.26	2.28	1.07	0.0294	0.0325	0

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 9.789	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 9.789	$ 9.954	0.95	0.09	1.86	0.70	0.032	0.0319	0
$ 9.954		0	0.26	2.28	1.07	0.0294	0.0325	0

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	methionine
$ -	$ 8.493	1.44	0	1.65	0.51	0.0333	0.0315	0.000655
$ 8.493	$ 8.661	0.95	0.09	1.86	0.70	0.032	0.0319	0
$ 8.661		0	0.26	2.28	1.07	0.0294	0.0325	0

Table B.10. Least-cost ration solution for 80-140 pound hogs in Oklahoma

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 7.337	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	0
$ 7.337	$ 9.141	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	0
$ 9.141	$ 9.307	1.78	0.14	2.51	0.45	0.0336	0.042	0	0
$ 9.307	$ 9.557	0.004	0.46	3.29	1.14	0.0289	0.0433	0	0
$ 9.557		0	0.46	3.29	1.14	0.0289	0.0433	0	0.000013

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 8.151	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	0
$ 8.151	$ 9.784	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	0
$ 9.784	$ 9.948	1.78	0.14	2.51	0.45	0.0336	0.042	0	0
$ 9.948	$ 10.200	0.004	0.46	3.29	1.14	0.0289	0.0433	0	0
$ 10.200		0	0.46	3.29	1.14	0.0289	0.0433	0	0.000013

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 6.524	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	0
$ 6.524	$ 8.499	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	0
$ 8.499	$ 8.667	1.78	0.14	2.51	0.45	0.0336	0.042	0	0
$ 8.667	$ 8.915	0.004	0.46	3.29	1.14	0.0289	0.0433	0	0
$ 8.915		0	0.46	3.29	1.14	0.0289	0.0433	0	0.000013

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 7.696	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	0
$ 7.696	$ 9.789	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	0
$ 9.789	$ 9.954	1.78	0.14	2.51	0.45	0.0336	0.042	0	0
$ 9.954	$ 10.191	0.004	0.46	3.29	1.14	0.0289	0.0433	0	0
$ 10.191		0	0.46	3.29	1.14	0.0289	0.0433	0	0.000013

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 6.979	2.60	0	2.07	0.21	0.0341	0.0417	0.000720	0
$ 6.979	$ 8.493	2.11	0.08	2.37	0.32	0.0345	0.0417	0.000448	0
$ 8.493	$ 8.661	1.78	0.14	2.51	0.45	0.0336	0.042	0	0
$ 8.661	$ 8.923	0.004	0.46	3.29	1.14	0.0289	0.0433	0	0
$ 8.923		0	0.46	3.29	1.14	0.0289	0.0433	0	0.000013

Table B.11. Least-cost ration solution for 140-190 pound hogs in Oklahoma

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 5.047	3.79	0	2.14	0	0.0291	0.0498	0	0
$ 5.047	$ 5.101	3.53	0.04	2.36	0	0.0305	0.0497	0	0
$ 5.101	$ 7.337	3.27	0.08	2.58	0	0.032	0.0495	0.0001105	0
$ 7.337	$ 7.416	3.07	0.11	2.70	0.04	0.0321	0.0495	0	0
$ 7.416	$ 9.307	2.07	0.28	3.32	0.26	0.0331	0.0496	0	0
$ 9.307	$ 9.557	0.36	0.58	4.07	0.92	0.0286	0.0508	0	0
$ 9.557		0	0.63	4.24	1.06	0.0277	0.0511	0	0.00121

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 6.069	3.79	0	2.14	0	0.0291	0.0498	0	0
$ 6.069	$ 6.119	3.55	0	2.37	0	0.306	0.0544	0	0
$ 6.119	$ 6.126	3.53	0.04	2.36	0	0.0305	0.0497	0	0
$ 6.126	$ 8.151	3.27	0.08	2.58	0	0.032	0.0495	0.0001105	0
$ 8.151	$ 8.228	3.07	0.11	2.70	0.04	0.0321	0.0495	0	0
$ 8.228	$ 9.948	2.07	0.28	3.32	0.26	0.0331	0.0496	0	0
$ 9.948	$ 10.200	0.36	0.58	4.07	0.92	0.0286	0.0508	0	0
$ 10.200		0	0.63	4.24	1.06	0.0277	0.0511	0	0.00121

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 4.016	3.79	0	2.14	0	0.0291	0.0498	0	0
$ 4.016	$ 4.071	3.53	0.04	2.36	0	0.0305	0.0497	0	0
$ 4.071	$ 6.521	3.27	0.08	2.58	0	0.032	0.0495	0.0001105	0
$ 6.521	$ 6.601	3.07	0.11	2.70	0.04	0.0321	0.0495	0	0
$ 6.601	$ 8.664	2.07	0.28	3.32	0.26	0.0331	0.0496	0	0
$ 8.664	$ 8.912	0.36	0.58	4.07	0.92	0.0286	0.0508	0	0
$ 8.912		0	0.63	4.24	1.06	0.0277	0.0511	0	0.00121

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 5.047	3.79	0	2.14	0	0.0291	0.0498	0	0
$ 5.047	$ 5.101	3.53	0.04	2.36	0	0.0305	0.0497	0	0
$ 5.101	$ 7.696	3.27	0.08	2.58	0	0.032	0.0495	0.0001105	0
$ 7.696	$ 7.776	3.07	0.11	2.70	0.04	0.0321	0.0495	0	0
$ 7.776	$ 9.954	2.07	0.28	3.32	0.26	0.0331	0.0496	0	0
$ 9.954	$ 10.191	0.36	0.58	4.07	0.92	0.0286	0.0508	0	0
$ 10.191		0	0.63	4.24	1.06	0.0277	0.0511	0	0.00121

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day							
min	max	peas	barley	corn	sbm	dical	limestone	methionine	lysine
$ -	$ 5.047	3.79	0	2.14	0	0.0291	0.0498	0	0
$ 5.047	$ 5.101	3.53	0.04	2.36	0	0.0305	0.0497	0	0
$ 5.101	$ 6.979	3.27	0.08	2.58	0	0.032	0.0495	0.0001105	0
$ 6.979	$ 7.056	3.07	0.11	2.70	0.04	0.0321	0.0495	0	0
$ 7.056	$ 8.661	2.07	0.28	3.32	0.26	0.0331	0.0496	0	0
$ 8.661	$ 8.923	0.36	0.58	4.07	0.92	0.0286	0.0508	0	0
$ 8.923		0	0.63	4.24	1.06	0.0277	0.0511	0	0.00121

Table B.12. Least-cost ration solution for 190-260 pound hogs in Oklahoma

Base case prices for corn, barley, soybean meal

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 5.047	4.88	0	1.83	0	0.0175	0.0561	0
$ 5.047	$ 7.416	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 7.416	$ 9.307	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 9.307	$ 9.557	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 9.557		0	0.79	5.05	0.86	0.0264	0.0558	0.00098

Increase prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 6.613	4.88	0	1.83	0	0.0175	0.0561	0
$ 6.613	$ 8.625	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 8.625	$ 10.231	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 10.231	$ 10.501	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 10.501		0	0.79	5.05	0.86	0.0264	0.0558	0.00098

Decrease prices of corn and barley by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 4.020	4.88	0	1.83	0	0.0175	0.0561	0
$ 4.020	$ 6.604	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 6.604	$ 8.667	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 8.667	$ 8.915	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 8.915		0	0.79	5.05	0.86	0.0264	0.0558	0.00098

Increase price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 5.047	4.88	0	1.83	0	0.0175	0.0561	0
$ 5.047	$ 7.776	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 7.776	$ 9.954	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 9.954	$ 10.191	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 10.191		0	0.79	5.05	0.86	0.0264	0.0558	0.00098

Decrease price of soybean meal by 1 standard deviation

Price of peas		lbs/day						
min	max	peas	barley	corn	sbm	dical	limestone	lysine
$ -	$ 5.047	4.88	0	1.83	0	0.0175	0.0561	0
$ 5.047	$ 7.056	2.49	0.37	3.84	0	0.0307	0.0544	0
$ 7.056	$ 8.661	1.88	0.47	4.22	0.13	0.0313	0.0545	0
$ 8.661	$ 8.923	0.29	0.75	4.92	0.75	0.0271	0.0556	0
$ 8.923		0	0.79	5.05	0.86	0.0264	0.0558	0.00098