Understanding soybean meal: Value-added benefits in the swine industry

Frequently Asked Questions

This document was funded by the United Soybean Board and is based on extensive research and decades of real-world commercial application. It represents the collective and collaborative efforts of seven swine-industry leaders, including:

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Purpose

Our goal in re-emphasizing soybean meal (SBM) as a key dietary ingredient for pig production is to raise awareness of the fact that extreme replacement of SBM with alternative protein sources such as corn coproducts and synthetic amino acids may impair performance and profit. SBM contains healthful, functional bioactive compounds that are not present in these alternative protein sources. This is especially true when maximum growth is needed or when respiratory disease is a recurrent problem. The benefits of including SBM in growing-pig diets have been proven for these specific conditions:

- During summer heat stress, to minimize or eliminate carcass weight dip
- When swine respiratory disease (SRD) is a recurrent problem, especially in winter to early spring or in the fall when influenza can be a problem. SBM attenuates the harmful effects of respiratory disease on growth rate and feed efficiency

We are not aware of a benefit to elevated SBM when time is adequate to achieve target market weight (e.g., early fall), with the exception of health-challenged pig flows due to SRD.

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Section 1: Feed Formulation and Soybean Meal (SBM) Inclusion Recommendations

S1.Q1: When did it become evident that too much displacement of soybean meal could impair swine performance?

When replacement of SBM by distillers' dried grains with solubles (DDGS) and/or synthetic amino acids in swine diets is too extreme, growth and feed conversion decline and thus profit is impaired. This was not recognized as a concern until tryptophan, the fourth essential amino acid, entered commercial use in 2013. The combination of tryptophan and DDGS caused dietary SBM volume to plummet by an additional 250–300 lbs/ton in growing and finishing diets.

S1.Q2: From a seasonal perspective, when does a minimum dietary SBM level benefit performance and economics?

The primary benefit of using higher SBM levels occurs during the summer months (May–September, depending on location). This timing minimizes the predictable reduction in carcass weight that results from suppressed feed intake due to heat stress (see Section 3). This effect (commonly referred to as the "summer dip") is well known and has typically been considered a persistent problem and a cost of doing business.

Higher SBM levels may also prove beneficial during winter and early spring (January–April) when swine respiratory disease (SRD) tends to be most active (see Section 2, Q2). SRD has a profound effect on gain and feed conversion, and optimum SBM levels can mitigate this problem. Respiratory disease growth suppression may also account for a premature carcass weight decline ahead of the summer months.

S1.Q3: What net energy (NE) and metabolizable energy (ME) values should be used for SBM in diet formulation?

It is recognized that NE values for SBM published in international references are too low, and not aligned with more recent animal growth experiments. More reliable estimates of both NE and ME for swine have been derived from growth assays and recently published in the June 2023 edition of Feedstuffs, Amino acid levels and energy specifications in SBM for poultry and pigs.

Given that SBM NE increases as SBM crude protein content increases, it is best to express NE as a percentage of the corn NE value, where the NE value is typically 85%–95% of corn NE. There is also evidence that the NE value expressed may be greater under commercial conditions when pig health is challenged. A conservative approach is to use the lower NE values published in Feedstuffs, and let the pig express the value through improved feed conversion if there is a health challenge. This simplifies formulation while also taking advantage of the SBM benefit on feed conversion (FCR).

S1.Q4: What is the suggested maximum level of synthetic L-lysine that should be used for each phase of growing and finishing?

The maximum level of synthetic L-lysine that should be used is the same, whether or not a minimum SBM level is set. These have been determined in practice for each phase of growth, and are shown in the table below. The number of feeding phases is greater than some systems use but can be reduced according to need.

The maximum limits for synthetic lysine are often exceeded, especially in pig weights of 200 lbs. or more. Feed invoice is a driving force, but skilled nutritionists have studied the consequences of exceeding the limits on both growth and feed conversion. With the new understanding, the suggested minimum SBM levels should only be applied under conditions of (1) summer heat stress or (2) when respiratory disease stress is a persistent problem. They do not apply to fall diets unless respiratory disease is a problem (e.g., influenza).

Minimum levels of SBM for heat stress were established by a large commercial system, since this normally represents the biggest profit opportunity (see Section 3, Q1). A specific and lower recommendation has also been provided for when respiratory stress is an issue (see Section 2, Q2). In each case, there is a significant benefit to carcass weight gain; FCR is also markedly improved during respiratory stress. Typical diets use too much DDGS and/or synthetic lysine; they displace SBM and the natural growth- and health-promoting functional bioactive compounds that it contains.

Maximum Synthetic L-Lysine Levels by Phase of Growth to Prevent Performance Loss

Diet Name	Start WT lbs/pigs	End WT lbs/pig	Max Lys. HCI lbs/ton
Diet 25-50	25	54	12.5
Diet 1	54	79	12.0
Diet 2	79	101	11.0
Diet 3	101	122	10.0
Diet 4	122	159	8.0
Diet 5	159	191	7.0
Diet 6	191	220	6.0
Diet 7	220	MKT	5.0

S1.Q5: Why should a minimum amount of SBM be included in growing and finishing diets when synthetic amino acids can be less expensive?

With the economic competitiveness of synthetic amino acids over the past decade, significantly higher levels have been used in swine diets, resulting in less predictable performance results. Exceeding maximum recommended levels of L-lysine HCl (and consequently not meeting recommended soybean meal/crude protein levels), particularly in late-finishing pigs (e.g., 180–300 lbs), can severely compromise growth and feed efficiency. SBM provides important functional bioactive compounds, as well as the proper balance of essential amino acids. Recent evaluations in a large production system indicated performance improvements when using minimum SBM levels in the summer months, which reduced the summer weight dip. Functional bioactive compounds contained in SBM have also provided performance improvements during health-challenged periods of the year (e.g., January–April).

S1.Q6: Is it better to use a minimum level of crude protein or a maximum level of L-lysine HCI in formulations?

The preferred method is to set maximum L-lysine limits, and then set appropriate ratios of the most limiting amino acids to the diet lysine specification. A second step is to set a minimum protein limit, to increase the confidence in obtaining more consistent performance. It is a current practice to set a minimum level of crude protein and maximum level of L-lysine HCl. However, when elevated SBM content is required to deliver health benefits, a crude protein minimum constraint is not recommended because alternative protein sources could meet a minimum protein constraint but with insufficient SBM. In this case, a minimum SBM constraint should be used.

S1.Q7: Do you recommend using (standardized ileal digestible) SID-lysine to NE ratios? What is the acceptable range?

Lysine:energy ratios are helpful and should be used for extreme energy level changes. However, the lysine:energy ratio must meet the needs of the specific pigs involved, because the pigs have a great propensity to "eat around" energy differences in their diet. The cost of maintaining energy in the diet, while allowing the use of lower energy ingredients, is much greater today because of higher fat and oil prices. The lysine:energy ratio is commonly used in the formulation process, but formulators must verify that their software settings allow the least-cost process to lower energy slightly to achieve least cost per unit of dietary energy. If the ratio is fixed, then in some cases the ratio will increase feed costs without performance benefits. If a formulator is not familiar with this issue, we recommend using NE and SID-lysine levels as the formulation pressure points (for a given production phase and genetic source) and routinely monitoring the ratio of SID Lysine to NE.

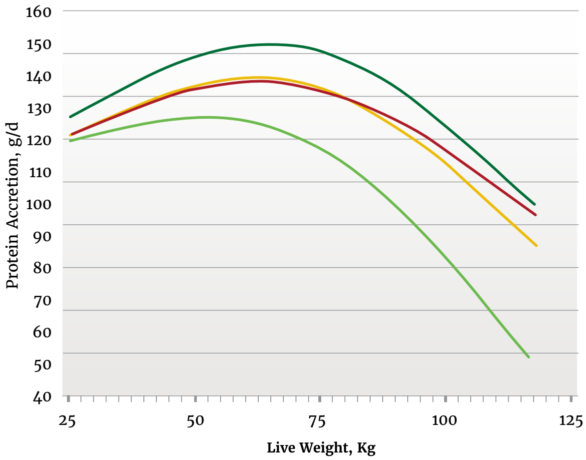
S1.Q8: Are branched-chain amino acids (BCAA) a concern when formulating finishing diets with a minimum amount of SBM?

BCAA are a minor concern, and formulating with a minimum level of SBM actually helps, as compared to using excessive levels of corn protein as DDGS. BCAA are less of a concern in finishing diets than in nursery diets. The primary formulation pressure should be on lysine, threonine, tryptophan, and methionine + cysteine. The BCAA imbalance that is created by using high DDGS levels becomes significant because it displaces SBM. SBM is important to preventing imbalance and the adverse effect an imbalance can cause.

S1.Q9: How will genotypes influence dietary nutrient levels and amount of SBM?

It is a well-established fact that different genotypes have different protein deposition rates (see graph). Animal nutritionists need to work with the genetic supplier to tailor nutrient levels to protein accretion rates. Currently, our understanding of SBM level in supporting performance during stressful periods (heat stress, health challenge) is not differentiated across genetic lines. If there is a difference, it is expected to be small and hard to determine.

Genetic Differences in Protein Accretion Rate



Differences in protein accretion rate between four different genetic lines.

—A —B —C —D

- Growth curve differences affect lean and fat disposition
- Plateau levels affect efficiency and optimum market weights

Schinckel, A.P. and C.F.M. De Lange. 1996. Characterization of growth parameters needed as inputs for pig growth models. Journal of Animal Science. 74:2021–2036.

Section 2. Swine Respiratory Disease

S2.Q1: With health-challenged flows, should the industry be using higher levels of soybean meal (SBM)?

SBM has proven beneficial in attenuating both the intake- and weight-gain-suppressing effects of respiratory health challenges, most likely due to the abundant supply of health-promoting functional bioactive compounds in SBM. As with any intervention that may help reduce the severity of the challenge, improvements in livability, morbidity, growth rate and feed efficiency are likely evident. In efforts to compensate for the ongoing challenge of swine respiratory diseases (SRD), typically higher levels (20%–25%) of SBM are recommended, and generally using a minimum amount of SBM in formulations will provide a favorable economic return, which can be verified by side-by-side barn comparisons.

S2.Q2: Since minimum SBM specifications are beneficial during both summer heat stress and respiratory stress, how do the recommended minimum SBM specifications compare?

Specific recommendations for minimum SBM levels for diets fed to pigs during heat stress and diets fed during respiratory disease stress differ. Specifications that pertain to periods of persistent respiratory disease are shown below. Specifications for summer heat stress are included in Section 3, Q1.

Suggested minimum SBM levels for periods of respiratory disease stress [e.g., Swine Influenza Virus (SIV), Mycoplasma hyopneumoniae (Mhp), Porcine Reproductive and Respiratory Syndrome (PRRS), Porcine Circovirus Associated Diseases (PCVAD)] were determined in a commercial system, but further research is needed. A major problem when implementing the minimums for the disease state is that the timing of disease occurrence varies — the greatest problem may occur during winter/early spring months (e.g., January–April). Guidance by a knowledgeable veterinarian, working in collaboration with the nutritionist, is essential to decide whether and when to apply SBM minimums in feed formulations in order to partially counter the effects of respiratory disease.

Note that the maximum levels of L-lysine shown in the table below are applicable to all seasons and do not vary with limits on SBM or dried distillers' grains with solubles (DDGS). Optimal L-lysine maximums have been determined in a number of commercial systems, but not all nutritionists are aware of this work and the performance effects. A minimum DDGS level is suggested based on field reports of improved bowel health.

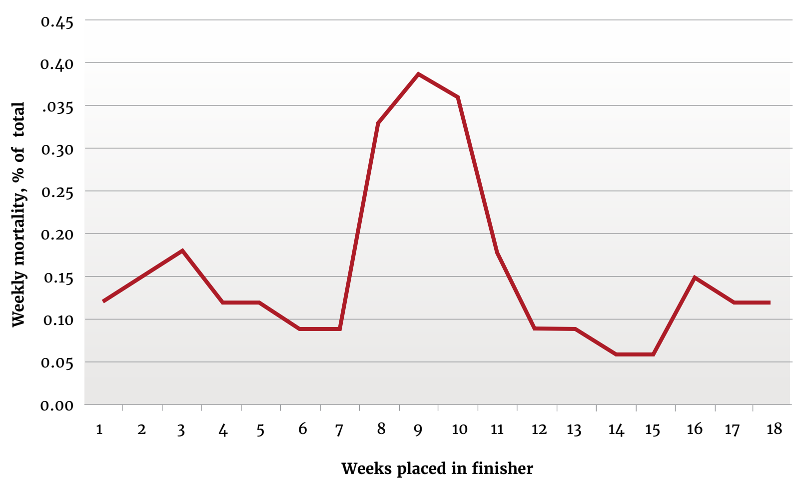
Diet Matrix for Respiratory Disease (including PRRS and PCVAD)

Diet Name	Start WT lbs/pigs	End WT lbs/pig	Max Lys. HCI lbs/ton	Min SBM lbs/ton	Min DDGS lbs/ton	Max DDGS lbs/ton
Diet 25-50	25	54	12.5	560	100	150
Diet 1	54	79	12.0	500	100	200
Diet 2	79	101	11.0	400	125	200
Diet 3	101	122	10.0	360	125	300
Diet 4	122	159	8.0	300	125	400
Diet 5	159	191	7.0	260	125	400
Diet 6	191	220	6.0	230	125	400
Diet 7	220	MKT	5.0	200	125	300

S2.Q3: When is it most common to experience respiratory-health-challenged flows?

Health challenges can occur all year long but probably the most predictable time across flows and systems would be during the winter months, when ventilation issues cause respiratory challenges to increase. These challenges are especially evident when sow farm health becomes unstable due to disease outbreak and/or lateral transfer in the wean-to-finish period. In large production systems, the most common production phases with observed health challenges are the: 1) first three weeks in the nursery, 2) mid-finishing, about 7–10 weeks post-placement, and 3) late-finishing, two to four weeks prior to harvest. Feeding the minimum recommended level of SBM is effective in attenuating the growth-suppressing effect of respiratory disease.

Monitoring Mortality Losses by Phase



Assumes pigs are placed at 55.1 lb and go to market at 291 lb: Gain, 1.87 lb/day; estimated close-out mortality of 2.8%
Data and personal communication sourced from large Midwest commercial system

S2.Q4: What are the functional bioactive compounds in SBM, and what evidence demonstrates their value in health-challenged pig flows?

SBM contains an abundant and diverse supply of growth- and health-promoting functional bioactive compounds that have antiviral, anti-inflammatory, antioxidant and immune-enhancing properties. Both academic and commercial research demonstrates that soybean meal is immunomodulatory when pigs are health-challenged. Research in poultry has demonstrated that the performance benefits are most likely due to the isoflavones present in SBM. For related information see:

Dietary Isoflavone Aglycons from Soy Germ Pasta Improves Reproductive Performance of Aging Hens and Lowers Cholesterol Levels of Egg Yolk

Immunomodulatory potential of dietary soybean-derived isoflavones and saponins in pigs

S2.Q5: Do processed soy products, such as soy protein concentrates, fermented soy products and so on (which are often used in nursery diets), contain functional bioactive compounds?

Processed soy products have some of the functional bioactive compounds removed and would not provide the same response as soybean meal. In addition, processed soybean products are typically more expensive and would not be cost-effective, other than, perhaps, in the early nursery phase.

S2.Q6: Are soybean meal's functional bioactive compounds more effective on respiratory or enteric health challenges?

Current evidence suggests that SBM has a profound effect when pigs are challenged by respiratory diseases. This has been proven by dramatic improvements in gain and feed efficiency, and a reduction in mortality and morbidity in nursery pigs, when fed diets with higher levels of SBM. More research is needed to determine if there are also enteric benefits. In addition, a growing body of evidence suggests that including soybean hulls in swine diets improves gut health.

S2.Q7: With the current understanding of the mode of action of functional bioactive compounds, are there other areas within pork production where higher levels of SBM may be beneficial?

Reduction in inflammation is key in many phases, but especially post-farrowing. Although research is needed, the level of SBM used during lactation could be an important "recovery application," providing value above the nutritional value SBM delivers. Given the respiratory outbreaks that occur on sow farms (i.e., PRRS and SIV), there could be merit in increasing soybean meal levels as well.

Section 3: Summer Carcass Weight Dip

S3.Q1: How do distillers' dried grains with solubles (DDGS) impact feed intake, and how should they be used in formulations with a minimum level of soybean meal (SBM) for summer feeding programs?

DDGS can be used successfully in swine diet formulations, but they cannot be used at a level greater than 10% in a summer feeding program without a significant reduction in carcass weight gain. Ingredients that increase dietary fiber content (NDF), such as DDGS, corn germ meal and wheat midds reduce feed intake. The extent to which feed intake declines is dependent on the specific dietary level, with intake reduction being slightly greater in the growing phase than in the finishing phase. Excessive levels of DDGS in growing diets (greater than 10%) and in late-finishing (greater than 15%–20%) pig diets will negatively affect growth, especially during the summer.

There are some large-scale studies conducted in production systems that have shown a benefit from limiting the amounts of DDGS fed during the summer months, in order to prevent a reduction in intake and average daily gain (ADG). Increasing SBM does not reduce feed intake. The feeding matrix used by one production company to eliminate summer carcass weight dip is shown below, with diets being less expensive than traditional summer diets.

Note that the maximum levels of L-lysine shown in the table are applicable to all seasons and do not vary with limits on SBM or dried distillers' grains with solubles (DDGS). Optimal L-lysine maximums have been determined in a number of commercial systems, but not all nutritionists are aware of this work and the performance effects. A minimum DDGS level is suggested based on field reports of improved bowel health.

Diet Matrix for Maximum Growth During Summer Heat Stress

Diet Name	Start WT lbs/pigs	End WT lbs/pig	Max Lys. HCI lbs/ton	Min SBM lbs/ton	Min DDGS lbs/ton	Max DDGS lbs/ton
Diet 25-50	25	54	12.5	580	100	100
Diet 1	54	79	12.0	640	100	100
Diet 2	79	101	11.0	610	125	125
Diet 3	101	122	10.0	580	125	125
Diet 4	122	159	8.0	480	125	125
Diet 5	159	191	7.0	410	125	200
Diet 6	191	220	6.0	320	125	200
Diet 7	220	MKT	5.0	180	125	250

S3.Q2: What are the major differences between summer and non-summer feeding programs related to SBM constraints?

The summer program involves a suggested minimum SBM and maximum DDGS content to minimize or prevent the carcass weight dip (see S3.Q1). The DDGS restriction is important because there is a dose-related reduction in feed intake, irrespective of source. However, a certain but greatly reduced level of DDGS is important to gut health. Growing and finishing pigs will consume 4%–8% less feed due to heat, and dietary fiber reduces intake even further. The diet matrix shown in S3.Q1 consists of corn, higher levels of SBM, some DDGS for gut health and no fat. Increasing amino acid levels is often recommended to compensate for reduced feed intake;

however, research has not proven this to be beneficial, unless amino acids are already below their required levels.

Recent changes in the cost of fats and oils have made it more difficult to justify the use of these ingredients based on benefit-over-feed cost. The SBM diet matrix eliminates the need for fat. To reiterate, the most important factor in carcass growth recovery is to not reduce feed intake in the first place.

S3.Q3: When should a summer feeding program be started?

Due to ambient temperature differences, the various "effective temperature" comfort ranges for each phase must be considered. In the Corn Belt region, putting summer diets in place by May and continuing through the month of September is recommended. In warmer regions, such as the Southeast and Southwest, putting summer diets in place in April may be more appropriate.

A mitigating factor is swine respiratory disease (SRD) prevalence. If producers have experienced a winter/spring challenge, then a carcass weight decline can emerge before it gets hot enough to reduce feed intake. This early start of carcass weight decline due to SRD becomes a calibrating factor for beginning the summer minimum SBM program to promote carcass growth. For example, in the Midwest, April may be a prudent choice to avoid creating a carcass weight dip that is difficult to overcome economically.

S3.Q4: Is there a different effect of SBM on gilts and barrows (and boars) in the summer-heat time?

A gender-by-season interaction has not been observed, but barrows will consistently consume more feed and grow faster than gilts. Boars have a higher protein accretion rate and lower feed intake in the early growth phases; thus, they will require higher amino levels (15%–25%) than barrows.

Section 4: Economics

S4.Q1: What is the preferred method to assess the financial aspects of a swine-feeding program?

Each system varies slightly in the methods used to assess the financial impact of its feeding program. Many times, income over feed costs is used, but the full analysis of all costs and revenue is crucial. For example, housing costs may be impacted by a more rapid growth rate (space shortages) so must be included. Various aspects of revenue will be impacted if the variation and percentage of full value pigs is considered. A complete evaluation of all feeding and production costs, including all sources of revenue, is suggested. The preferred method is calculating the net-profit-per-pig of a swine-feeding program.

S4.Q2: What are the shortcomings of using "income over feed costs" or "feed cost per lb of gain" when making financial decisions?

Often, nutritionists will use "income over feed costs" and "feed costs per lb of gain" as their financial measure of success. These methods typically overlook packer pricing factors — e.g., sort losses, lean premiums, group uniformity and leverage effects of heavier market weights. The shortcoming of using either one is knowing whether a particular system is fixed-time or fixed-weight, as the economics are different for each. In addition, neither metric alone fully accounts for the profit achieved on a per-pig basis.

S4.Q3: What is the additional economic value of using minimum soybean meal (SBM) levels rather than least-cost formulas using maximum levels of crystalline amino acids?

The primary benefit of using a minimum SBM level in formulations occurs during the summer, when it minimizes or eliminates the summer carcass weight dip. Extreme displacement of SBM by a higher fiber ingredient such as distillers' dried grains with solubles (DDGS) or corn germ meal reduces carcass weight gain. The second benefit tends to be in the winter months when barns are closed and respiratory diseases become a problem. When target carcass weight can be achieved with the typical diet, the analysis depends on ingredient costs and when SBM is used at higher levels. Under this scenario, maximum synthetic lysine levels are set only by dietary phase.

A recent comparison of costs and revenue for two different feeding programs aimed at optimizing carcass weight gain during the summer months — where one held a minimum SBM content and the other purely least-cost-formulated — indicated that after feed costs, carcass weight and mortality income were incorporated, the return per head was $2.99 greater when SBM minimums were enforced. The cost assumptions used were $5.96/bu corn, $400/ton SBM and $220/ton DDGS (derived from a three-year pricing history for a composite sampling of nine Midwest feed mills) and a carcass weight value of $1.00/lb. The challenge is capturing the anticipated tendencies of consistently better performance, especially in health-challenged flows or during summer months, compared to the higher feed costs.

SBM Economic Value: $ Return/Head

Market Prices, $/lb	Soybean Meal Cost/Ton, $						
	300	325	350	375	400	425	450
0.6	$2.89	$2.44	$1.64	$0.72	($0.28)	($1.28)	($2.28)
0.8	$4.52	$4.08	$3.27	$2.36	$1.36	$0.35	($0.65)
1	$6.16	$5.71	$4.91	$4.00	$2.99	$1.99	$0.99
1.2	$7.80	$7.35	$6.54	$5.63	$4.63	$3.63	$2.62

Assumes a 6.8 lb carcass weight advantage for minimum SBM, maximum DDGS specifications
Assumes .6% improvement in livability for minimum SBM, maximum DDGS specifications
Accounts for the added saleable pounds due to an improvement in livability
Assumes $5.96/bu corn, $220/ton DDGS
Assumes SBM NE equal to corn

Section 5: Full Value Pigs

- **S5.Q1: How is a producer's ability to produce more full value pigs impacted by having a minimum amount of soybean meal (SBM) added to finishing diets?**

  Added weight gain during the summer months shifts the entire population weight curve to the right, thus reducing the number of lower value pigs that fall outside the target weight range. Based on the typical packer-buying grids, it is quite common to receive sizeable light-pig discounts. In addition, as livability improves when using higher levels of soybean meal in pigs that are health-challenged, then the number of full value pigs should increase.

- **S5.Q2: How is carcass weight variation and carcass value impacted by having a minimum amount of SBM added to growing and finishing diets?**

  The value of SBM for improving carcass weight is highest during the summer, when the carcass weight dip occurs. Higher SBM levels generally lead to heavier carcass weights when used in late-finishing diets and/or under health-challenged conditions. The summer benefit of higher SBM is the result of reducing distillers' dried grains with solubles (DDGS) so that feed intake is not reduced. The benefit of higher SBM levels in winter diets, when respiratory disease is often a challenge, is that SBM attenuates the effects of disease on gain and feed efficiency.

- **S5.Q3: How are branded program quality specifications and export pass rates impacted by having a minimum amount of SBM added to the finishing diet?**

  Fat quality and marbling are generally the most significant factors in meeting branded program specifications and quality-based export pass rates. By having a minimum level of SBM in finishing diets and reducing the amount of DDGS and fats/oil, loin pass rates and bacon slicing efficiency tend to improve, resulting in enhanced value.

Section 6: Soybean Meal (SBM) Quality, Foreign Animal Disease (FAD) Biosecurity and Sustainability

- **S6.Q1: Is there a difference in SBM quality between vendors and/or countries?**

  There are little documented differences among U.S. vendors in SBM quality, but protein levels may vary by geographic areas. Every processor sets their own protein, fiber and moisture levels required for product sales, within the National Oilseed Processors Association (NOPA) guidelines. Requirements will differ by location, transportation costs and the economic model of the particular soybean processor. Differences can also be seen between countries based on soybean seed genetics, seasonal growing conditions, soybean processor practices and the carbon footprint associated with areas of deforestation. There are strong indications that some countries, such as China and Brazil, have more variable quality. Nutritionists need to be mindful of FADs and importation from other countries; however, robust standards, and travel/transportation and other protocols are in place, and continue to protect soy's feed customers and their swine herds. See Pork Industry Confirms Confidence in U.S. Soy.

S6.Q2: Does using SBM include a greater Foreign Animal Disease (FAD) biosecurity risk?

As long as the industry continues to invest heavily in biosecurity measures to maintain a FAD-free status, the risk when using U.S. SBM is low. While SBM may harbor viruses longer than other feedstuffs, synthetic amino acids could also be contaminated during manufacturing, storage or prior to shipment. Either condition could be problematic for the swine industry.

S6.Q3: How does more SBM in finishing diets affect greenhouse gases and carbon footprints?

It is important to remember that greenhouse gas emissions and carbon footprint values vary with ingredients used, as well as feed efficiency results. Generally, as feed efficiency improves, greenhouse gas emissions/lb of pork and carbon footprints are reduced. Diets that are higher in SBM also tend to have increased corn use, both of which are significantly lower in greenhouse gas than distillers' dried grains with solubles (DDGS) and synthetic amino acids. In addition, an increase in mortality will make feed efficiency results less attractive. See Life-cycle analysis of soybean meal, distiller-dried grains with solubles, and synthetic amino acid-based animal feeds for swine and poultry production for more information.

S6.Q4: How does including more SBM and slightly less synthetic amino acids in finishing diets impact manure production and manure management relative to the environment?

Manure production would not be expected to change. However, it is likely that manure nitrogen and mineral content would be slightly higher, due to more intact protein with soybean meal being fed as compared to a greater amount of crystalline amino acids. Currently, the lack of information on manure production among different diets is a limitation, and a constant value is used for manure production among all diets. This is an area ripe for additional investigation and research.