https://doi.org/10.54846/am2024/75

Soybean meal: Tactical option for swine respiratory disease mitigation: DVM perspective

Paul Yeske; Aaron Gaines; Jennifer Garret; R. Dean Boyd

Introduction

Soybean meal (SBM) is a superb amino acid and energy source for pig diets. Soybeans also contain an abundance of functional molecules (FM) in the non-nutritive fraction,[1] as well as bioactive peptides that arise during digestion of major SBM proteins.[2] There is considerable information on their benefits in relation to human health, but research with food animals is in the early stages of development.[3]

The disease-mitigating effects of SBM in pigs was reported in 2010 by researchers at the Hanor Company.[4,5] Swine respiratory disease infection (SRD) was unexpectedly encountered during a study with growing pigs that involved low SBM (typical) and high SBM diets. Pigs fed low SBM diets exhibited a profound loss in growth and feed conversion efficiency (FCE), which is common during periods of high immune stress. However, pigs fed diets with higher SBM content (38 - 50%) grew as though no active infection was present. These results were confirmed by another group who conducted a similar study design, almost simultaneous with ours, and who also encountered SRD pathogens unexpectedly (Gene Gourley, M.S., personal communication).

Results from the Hanor study exposed the hidden cost of SRD and illustrated the effectiveness of SBM in mitigating impaired growth. The observation that SBM can mitigate the effects of SRD is strengthened by results from a commercial study where the ability of pigs to thrive improved by increasing dietary SBM content.[6] SRD imposes significant hidden costs in FCE loss, increased medical treatment and potentially fewer pigs that thrive in late nursery through early growth. These costs are hidden because they are 'folded' into barn 'closeout' data, but they can add $3 - 6/pig to cost (range $2 - 9).

SRD complex is prevalent in many North American systems during January - April, when barns are closed for cold weather. The most problematic swine respiratory diseases include *Mycoplasma hyopneumoniae*, porcine reproductive and respiratory syndrome (PRRSV), influenza A virus in swine, *Streptococcus suis*, *Hemophilus parasuis*, and *Actinobacillus suis pleuropneumoniae*. Influenza is also a problem in the fall for some systems, but the economic cost of winter-spring SRD tends to be more persistent.

The Hanor study

The original experiment was designed to determine whether SBM level was a factor in meeting the dietary lysine requirement for pigs fed the metabolic modifier, ractopamine hydrochloride (RAC). In other words, did the level of dietary lysine required to maximize growth and FCE depend on the amount of SBM used to meet the lysine requirement? The simultaneous investigation of response to dietary lysine and SBM level was a fortunate design feature when SRD infection was unexpectedly encountered. Given this circumstance, the question evolved beyond how amino acid specifications were met to whether the nutraceutical components of SBM could mitigate respiratory disease impaired growth. In the end, the high SBM (H-SBM) regimen profoundly improved the level of growth and FCE achieved when compared to low SBM (L-SBM) fed pigs.

Study design

Dietary treatments were arranged as a 4 x 2 factorial; having 4 standardized ileal digestible (SID) lysine levels and 2 SBM levels (L-SBM, H-SBM). Pigs in all 8 diet subclasses were fed RAC (5 ppm) with whole-body growth rate (ADG), FCE and carcass gain being the key measures. A total of 420 castrate pigs (PIC terminal genetics) with an average body weight of 217 lbs were used. Data were collected each week for 21 d, after which all pigs were harvested. The commercial research facility that Hanor used was an academic equivalent setting, since pig density (room, pen) was low and environmental stressors normally encountered in commercial sites were reduced. The latter was accurate until we encountered an active infection of SRD complex of pathogens. The experimental framework is shown in Table 1.

Diet formula design

Diets were formulated to provide 0.65, 0.75, 0.85 or 0.95% SID lysine for both SBM regimens. The level of SBM and crude protein (CP) for each diet subclass is shown in Table 2. Diet composition is shown in Table 3. Four diets were manufactured, and summit blended at the research farm to create the 8 experimental diets using Feed Logic equipment. Details of dietary nutrient content are available in the paper by Boyd and Gaines.[7] Nutrient level was confirmed by analysis.

Unexpected infection with multiple respiratory pathogens

Pigs unexpectedly became infected with multiple respiratory pathogens (SRD complex) that triggered systemic inflammation. SRD causes growth and FCE to plummet compared to what is typical for unaffected pigs. Upon learning of the infection, all pigs received medication by water and clinical diagnostics and physical inspection of pigs was initiated under the direction of Tara Donovan, DVM (The Hanor Co). Serology revealed that pigs were PRRSV and porcine circovirus (PCV2) positive. There were PCV2 lesions and *Streptococcus suis* infection was also confirmed. The inflammatory nature of these viruses has been proven by the presence of circulating pro-inflammatory cytokines.[8]

The study continued as planned because SRD infection is a production reality. In North America, SRD complex is prevalent in many systems when barns are closed due to cold weather. In addition, SRD is often a problem for weaned pigs that are derived from PRRSV active sow farms. Taken together, SRD infection can span 6 - 7 months of the year.

SBM mitigated respiratory disease-impaired growth

The overall effect of SBM level on whole-body and carcass growth and FCE is shown in Table 4. Since the response to dietary lysine level was similar for both SBM levels (SBM x lysine level, $P > .29$, all criteria), the average response to SBM level is shown for the 21-d study. The growth suppressing effects of SRD is illustrated

Table 1: Factorial arrangement of dietary lysine and soybean meal (SBM) level diets

	SID lysine,[1,2] %				Total pens and pigs	
Diet SBM level	0.65	0.75	0.85	0.95	EU pens	Pigs[3]
Low	6 (52)	6 (53)	6 (52)	6 (53)	24	210
High	6 (52)	6 (53)	6 (52)	6 (53)	24	210

[1] Standardized ileal digestible, SID.

[2] Experimental unit pens of pigs shown prior to parenthesis. Total pigs per treatment subclass is shown in parenthesis.

[3] Average initial whole-body weight for treatments, 216 ± 1.5 lbs.

Table 2: Level of dietary soybean meal (SBM) and crude protein (CP) content

		SID lysine,[1] %			
Diet SBM level	**Unit**	0.65	0.75	0.85	0.95
Low	lbs/ton	273	316	362	406
High	lbs/ton	374	462	553	637
Low	CP, %	16.0	16.0	16.0	16.0
High	CP, %	16.0	17.4	18.7	20.1

[1] Standardized ileal digestible, SID.

Table 3: Ingredient composition of summit blend diets[1]

Diet[2]	**1**	**4**	**5**	**8**
SID Lysine, %	**0.65**	**0.95**	**0.65**	**0.95**
Ingredient, lbs/ton	**Low SBM**		**High SBM**	
Corn ground, 8.5%	1521	1474	1482	1239
Soybean meal, 47.5%	273	406	374	637
Corn gluten, 62.0%	109	0	39	0
L-lysine.HCl	2.5	7.0	0	0
L-threonine	0	3.0	0	0
DL-methionine	0	1.5	0	0
Choice white grease	46	61	58	80
Mono-calcium Phos.	21.5	20.9	21.0	19.6
Limestone	16.7	15.8	16.0	14.2
Salt	8.0	8.0	8.0	8.0
VTM premix	2.0	2.0	2.0	2.0
Ractopamine, 9 g/lb	0.5	0.5	0.5	0.5
Total	**2000**	**2000**	**2000**	**2000**

[1] Standardized ileal digestible, SID.

[2] Diets 1, 4 were manufactured and blended by Feed Logic equipment to derive diets 2, 3. Diets 5, 8 were likewise blended to derive diets 6, 7.

Table 4: Main effect of SBM level on whole-body and carcass growth in pigs fed the metabolic modifier, ractopamine for 21 d [1,2]

Item	Unit	Low SBM	High SBM	SEM	Probability, less than	% advantage
No. pens	–	24	24	–	–	–
No. pigs	–	210	210	–	–	–
Initial body weight	lbs/pig	216.9	216.5	1.6	0.88	–
Whole-body ADG[3]	lbs/d	1.99	2.18	0.1	0.04	9.5
Whole-body FCE[3]	ratio	2.97	2.74	0.1	0.05	- 7.7
Initial carcass est [4]	lbs/pig	160.9	160.9	–	–	–
Carcass yield[5]	%	74.6	74.7	0.50	ND	–
Carcass weight	lbs/pig	192.4	196.2	1.4	0.05	2.0
Carcass ADG[3]	lbs/d	1.33	1.50	0.1	0.09	12.8
Carcass FCE[3]	ratio	4.35	3.93	0.1	0.05	- 9.7

[1] Dietary SBM levels are shown in Table 2.
[2] Least squares means calculated using whole-body initial weight as covariate.
[3] ADG = average daily gain; FCE = feed conversion efficiency ratio, FCE, calculated as feed/gain.
[4] Initial carcass weight estimated by multiplying initial live body weight x 0.745
[5] Calculated as carcass weight (head on) at plant/live weight at the research site (< 12 h to loading)

by comparing the response of L-SBM and H-SBM diets; the latter resulted in profound improvements in whole-body (ADG, +9.5%; FCE, -7.7%) and carcass growth (ADG, +12.8%; FCE, -9.7%).

The net result of H-SBM diets, during the infection, was improved carcass weight gain (3.8 lbs/pig) and significant feed savings. If H-SBM fed pigs were harvested on a weight constant basis to L-SBM pigs (31.5 lbs carcass gain/pig), they would have required 13.2 lbs less feed per pig.

This was the first study to show that SBM can reduce high immune stress-impaired growth. Until this report,[9] efforts to reduce disease impaired growth by nutritional means had been unremarkable. We propose that SBM is a nutritional and 'prescriptive' ingredient when SRD is encountered in commercial practice; prescriptive, meaning that SBM is a credible, tactical option for respiratory disease mitigation in pigs (term first suggested by Dr. Lisa Weaver, personal communication).

Growth response was dependent on SBM level

Although the shape of FCE response curves was similar for both SBM regimens, dietary SBM level caused the curves to separate into 2 planes of genetic expression (Figure 1). The same pattern was observed for growth rate (Figure 2). This suggests an important principle in relation to genetic expression when confronted with disease. SBM content influenced the level of growth permitted, with growth depending next on amino acid intake. To illustrate, when higher lysine levels (amino acids) were fed to improve performance by apparently less healthy pigs (L-SBM), FCE and ADG became worse not better (Figures 1, 2). Stated alternatively, attempting to overcome health constrained growth is counterproductive.

In the hierarchy of growth regulation, amino acid intake is important but secondary to health status. Physiologically, the body responds to systemic immune stress by prioritizing nutrients for life-sustaining processes overgrowth (eg, IGF-1 declines.[9,10] Ultimately, amino acid intake provides the building blocks for muscle growth that health status permits.

Basis for disease mitigating effects of SBM

The biological basis for the mitigating effects of SBM on SRD impaired growth is unclear, but it is unlikely to be nutritional. SBM level, not nutrient content, is the variable in play and the difference in SBM functional molecules (FM) intake is markedly different between SBM levels. These components are most likely involved in mitigating mechanisms. Functional molecules in SBM are remarkably diverse and abundant. The isoflavone (ISF) fraction of FM was used as a 'marker' to track relative FM differences between SBM levels over the lysine response curve. The disparity in ISF content between dietary cohorts increased as lysine level increased (Figure 3).

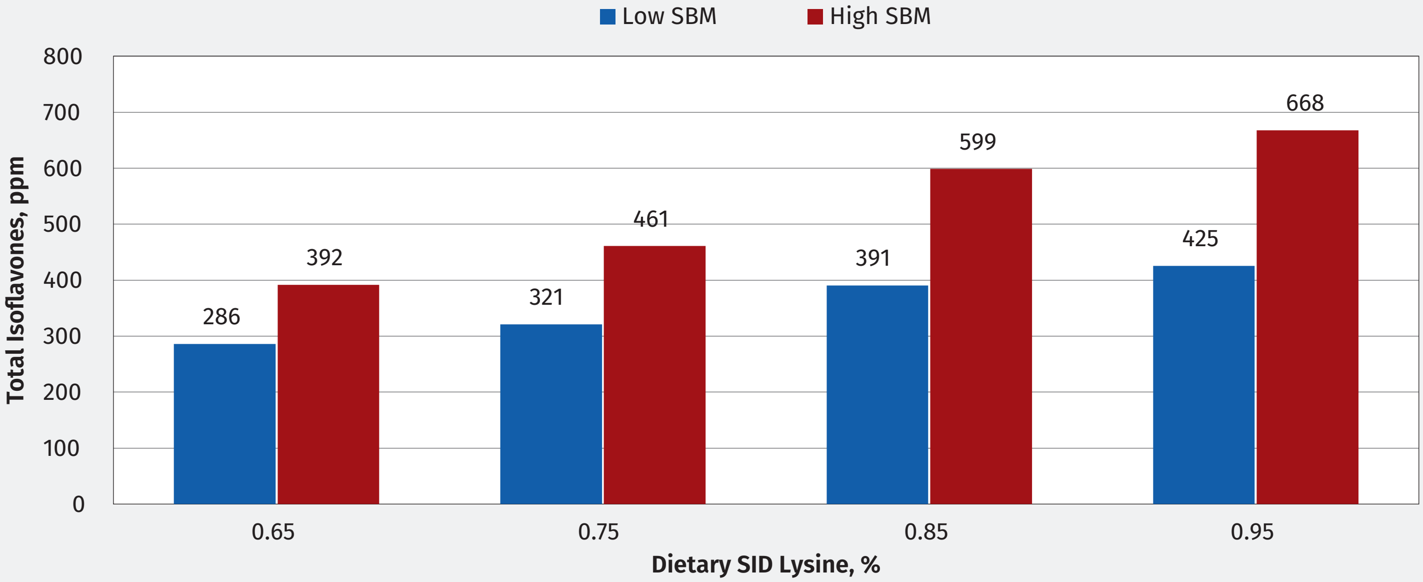
Possible mechanisms for disease mitigation by functional molecules

We are indebted to human medical research for our understanding of disease mitigating mechanisms of soybeans. A variety of disease-uncoupling actions are exerted simultaneously by an equally diverse set of FM. Some mechanisms improve or balance the animal's survival response to infection (no. 2, 3, 4 below), while other mechanisms operate to reduce pathogen concentration (no. 1). Disease mitigation mechanisms include:[2]

1. Anti-viral
2. Oxidation stress reduction
3. Anti-inflammatory
4. Improve function of existing immune cells
5. Preserve intestinal barrier integrity

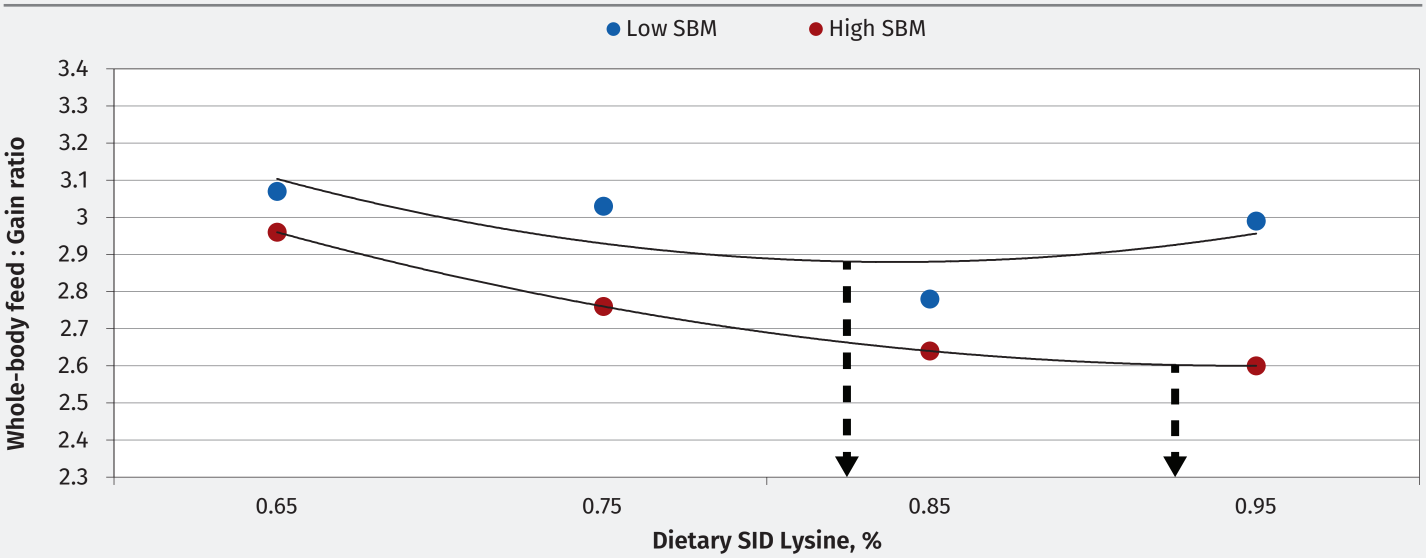
Control of systemic disease requires multiple countering mechanisms that act in concert to reduce the damaging effects of pathogens. The respiratory disease complex that was encountered in the Hanor study involved at least 3 known pathogens (virus, bacteria). Multiple pathogen infection tends to be the norm.

Figure 1: Total isoflavone content for experimental diets based solely on the contribution by SBM.



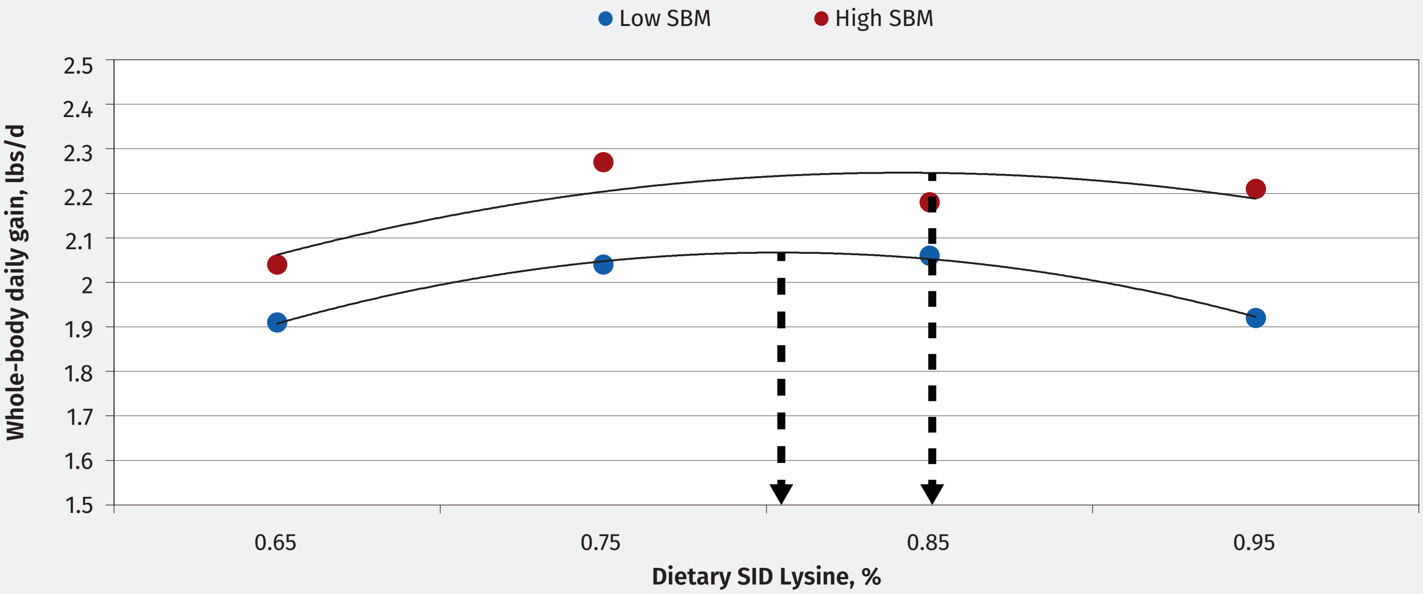
Total isoflavone (ISF) content of diets is based on the contribution by SBM and symbolizes the difference in content of all SBM functional molecules between high and low SBM diets. The value shown is the sum of 3 major ISF, genistein, daidzein and glycitein. Level of each ISF was derived from the review by Smith and Dilger.

Figure 2: Whole-body feed efficiency response for growing pigs receiving Ractopamine (5 ppm) for 21 d: Response to dietary SBM and lysine levels during an active respiratory infection.



Dietary level of SBM for each lysine level treatment is shown in Table 2. Arrows show the response maximum feed conversion efficiency (FCE) for both SBM levels. The absolute dietary SID lysine requirement to achieve maximum FCE response is 0.84 and 0.94% for low and high SBM curves respectively.

Figure 3: Whole-body daily gain response for growing pigs receiving Ractopamine (5 ppm) for 21 d: Response to dietary SBM and lysine level during an active respiratory disease infection.



Dietary level of SBM for each lysine level treatment is shown in Table 2. Arrows show the response maximum growth rate (ADG) for both SBM levels. The absolute dietary SID lysine requirement to achieve maximum ADG is 0.80 and 0.85% for low and high SBM curves respectively.

Applying the Hanor Study to other herds

This research provides an answer to the often-asked question, 'can anything be done nutritionally to improve growth when disease is encountered. Diet SBM content, rather than elevated amino acid (or energy) intake, is a means of profoundly mitigating growth suppression by the SRD complex. The financial value of tactical SBM use can be determined by comparing performance for **(1)** system diets and **(2)** prescriptive diets (system diets plus 30% more SBM in each diet to finish). Diets need to be equally applied by site and sex, using large numbers and in the time frame specified by the Veterinarian(s). Key measures are tracked to compute the financial outcome (eg, 1000 pig basis), including full-value (FVP) and cull-value pig market revenue, total diet cost and medication cost.

Carcass weight is a priority measure. Although growth rate is reflected in FVP carcass pounds, the diet effect on population carcass weight is important because a decline can begin to emerge even prior to summer heat stress. The motive is to see if the system is experiencing a leading edge to summer carcass weight dip (later article in this series). Carcass weight decline can begin to appear in April when heat is not yet a problem and becomes worse during summer. The reason for a premature decline in carcass weight can be confusing, but it could be due to unchecked SRD impaired growth. Summer carcass weight dip is a very costly problem; one that is preventable provided that pre-summer carcass weight decline is controlled.

Acknowledgments

This paper was adapted from a more comprohensive article published in Feedstuffs in October, 2023. **https://informamarkets.turtl.co/story/feedstuffs-october-2023/page/1**

These materials are (partially) funded by the United Soybean Board.

References

1. Sharma, R., S. Kumar, V. Kumar and A. Thakur. 2019. Comprehensive review on nutraceutical significance of phytochemicals as functional food ingredients for human health management. *J. Pharma. Phytochem*. 8 (5):385-395. **http://doi.org/10.22271/phyto.2019.v8.i5h.9589**

2. Chatterjee, C., S. Gleddie and C-W Xiao. 2018. Soybean bioactive peptides and their functional properties: Review. *Nutrients 10* (9):1211-1227. **http://dx.doi.org/1.3390/nu10091211**

3. Smith, B.N. and R.N. Dilger. 2018. Immunomodulatory potential of dietary soybean-derived isoflavones and saponins in pigs. *J. Anim. Sci*. 96:1288-1304. **http://doi.org/10.1093/jas/skyy036**

4. Johnston, M.E., R.D. Boyd, C. Zier-Rush, and C.E. Fralick. 2010. Soybean meal level modifies the impact of high immune stress on growth and feed efficiency in pigs. *J Anim. Sci*. 88 (E-Suppl. 3):174.

5. Boyd, R.D., M.E. Johnston and C. Zier-Rush. 2010. Soybean meal level modulates the adverse effect of high immune stress on growth and feed efficiency in growing pigs. Proc. 71st Minn. *Nutrition Conf.* pp. 167-174. U. Minn., St. Paul Minnesota. **https://hdl.handle.net/11299/204236x**

6. Cemin, H. S., H. E. Williams, M. D. Tokach, S. S. Dritz, J. C. Woodworth, J. M. Derouchey, K. F. Coble, B. A. Carrender, and M. J. Gerhart. 2020. Estimate of the energy value of soybean meal relative to corn based on growth performance of nursery pigs. *J. Anim. Sci*. Biotech 11:70-78. **https://doi.org/10.1186/s40104-020-00474-x**

7. Boyd, R.D. and A.M. Gaines. 2023. Soybean meal NE value for growing pigs is greater in commercial environments. *Feedstuffs*, August digital edition, page 1. **https://informamarkets.turtl.co/story/feedstuffs-august-2023/page/2/1**

8. Parra, M.D., P. Fuentes, F. Tecles, S. Martinez-Subiela, J.S. Martinez, A. Munoz and J.J. Ceron. 2006. Porcine acute phase protein concentrations in different diseases in field conditions. *J. Vet. Med*. B 53:488-493.

9. Johnson, R.W. 1997. Inhibition of growth by pro-inflammatory cytokines: An integrated view. *J. Anim. Sci*. 75:1244-1255

10. Spurlock, M.E. 1997. Regulation of metabolism and growth during immune challenge: An overview of cytokine function. *J. Anim. Sci*. 75:1773-1783.