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# Dietary Manipulation To Reduce Ammonia Concentration in Nursery Pig Facilities

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PHY and 85, NEG or MIN for carcass lean percentage or daily lean gain. There was no effect of experimental treatments on the number of pigs that died or were removed for poor performance during the experiment. Overall death loss and removal was 3.7%.

In this experiment, all treatments except UNL were designed to have lysine as a growth limiting nutrient. The claim for a .01% increase in lysine availability due to phytase addition was not supported as evidenced by the lack of improvement in performance for the MIN vs PHY treatments or the 85 vs PHY treatments.

Furthermore, the lysine limitation in the PHY treatment appears to have

been severe enough to prevent any response of phytase in improving calcium and phosphorus availability. The lack of a response to the experimental diets on bone breaking strength and bone ash (Table 4), both considered sensitive indicators of phosphorus availability, supports this conclusion. The fact that MIN was not superior to NEG for any of the traits reported further supports the conclusion that the lysine limitation was severe enough to limit the possible phytase response.

### Conclusion

These results document the impact of inadequate lysine on growth

and carcass lean. They do not agree with the large body of evidence regarding the improvement in corn and soybean meal phosphorus availability with the addition of phytase to swine diets. They do suggest a limited, if any, response to phytase additions in diets in which lysine is limiting performance. The results were also unable to document the improvement in calcium, energy and lysine availability previously reported in poultry experiments from the addition of phytase to corn and soybean meal based diets.

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# Dietary Manipulation To Reduce Ammonia Concentration in Nursery Pig Facilities

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## Summary and Implications

Five trials were conducted to determine the effects of *Yucca schidigera* extract or calcium chloride addition to the diet on aerial ammonia concentration and growth performance in nursery pigs. Trials were divided into two groups: preliminary studies (two trials) and major study (three trials). Pigs were fed one of three diets in separate, environmentally regulated rooms: 1) Control, containing 23% CP; 2) Control diet plus 125 ppm of *Yucca schidigera* extract; and 3) Control plus 1.95% calcium chloride. Average daily gain (ADG), average daily feed intake (ADFI), and ADG/ADFI were recorded weekly. Aerial ammonia concentration was measured daily using aspiration detector tubes and during the last week of each trial using diffusion tubes. Blood samples were collected at the end of each trial to determine plasma

urea concentration. There were no differences in ADG, ADFI, and ADG/ADFI between pigs fed the control diet and pigs fed the *Yucca schidigera* diet. In all trials, pigs fed the calcium chloride diet had lower ADG and ADG/ADFI than pigs fed the other two diets ( $P < .05$ ). In the preliminary studies (Trials 1 and 2), aerial ammonia concentration tended to be greater in the rooms in which pigs were fed the control diet than in the rooms with pigs fed the yucca extract diet ( $P < .08$ ) or calcium chloride diet ( $P < .11$ ). In the major study (Trials 3, 4, and 5), aerial ammonia concentration increased as the experiment progressed ( $P < .001$  in all rooms. In the fourth week, ammonia concentrations were greater ( $P < .001$ ) in the rooms that housed pigs fed the control diet than in the rooms in which the other two diets were fed. Dietary treatment did not affect plasma urea concentration ( $P > .10$ ). This research has shown that ammonia concentration in nursery pig facilities can be reduced by dietary manipulation such as the addition of *Yucca schidigera* extract or calcium salts.

## Introduction

Ammonia is one of the gases of most concern in swine buildings and is a major source of indoor air contamination. The large variation in aerial ammonia concentration is influenced by the bacterial activity and the presence of ideal fermentation conditions. Ammonia volatilization is a process that depends on factors such as concentration of aerial ammonia, air speed in the building, ammonia and dry matter content in the manure, pH of manure, and slurry temperature.

In addition to objectional odors, there also is concern about the health problems that ammonia exposure may produce in animals and animal caretakers. We reported a review of the ammonia issue and pork production in the Nebraska Swine Report (1999) and identified a clear need to continue to evaluate methods to reduce and control odor from livestock enterprises, especially pork production units. These methods include reducing of ammonia concentration using certain additives in growing pig diets such as *Yucca*

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*schidigera* extract or calcium salts. These additives have been successful in reducing ammonia concentrations in growing pig facilities by 26 and 33%, respectively. By adding calcium salts such as calcium chloride to the diet, the dietary electrolyte balance can be reduced. Dietary mineral balance may be expressed as Na+K-Cl (hereafter referred to as electrolyte balance) which considers the monovalent minerals ions in the diet. Diets with high levels of protein and amino acids that are typical for nursery-age pigs can increase the amount of nitrogen excreted in urine and feces, and this can increase ammonia production. Based on these observations, we designed a study to determine the effect of *Yucca schidigera* extract and calcium chloride addition to nursery diets on aerial ammonia concentration.

### Procedures

This research consisted of five trials: two preliminary four-week trials (preliminary study) and three, five-week trials (major study). The objective of the preliminary trials was to establish the ammonia concentration in our environmentally regulated nursery pig facilities. Information about each trial is presented in Table 1. In all trials, pigs were blocked on initial weight and allotted to one of three environmentally controlled rooms such that the average initial weight within each room was similar. In the major study, the three trials, three rooms, and three dietary treatments constituted a Latin square design such that each treatment was assigned in turn to each room.

Pigs were weighed and feed disappearance was recorded weekly to determine average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (ADG/ADFI). During the first week of each trial, all pigs were fed the same standard commercial prestarter diet (23.5% CP, 1.75% lysine, .75% Ca, and .70% P, with apramycin [as apramycin sulfate, 150 g/T]), to allow them to adapt to the

**Table 1. Details of the five trials conducted to determine the effects of the addition of *Yucca schidigera* extract or calcium chloride to nursery diets.**

Trial	Purpose	Duration wk <sup>a</sup>	Pigs per pen (barrows, gilts) <sup>b</sup>	Weaning age, d	Weaning wt, lb
1	Preliminary	1 + 3	6,0	15	11.4
2	Preliminary	1 + 3	6,4	13	6.6
3	Major	1 + 4	7,3	13	7.7
4	Major	1 + 4	6,4	15	13.0
5	Major	1 + 4	5,5	14	10.5

<sup>a</sup>Each trial consisted of a 1-wk initial period followed by a 3- or 4-wk experimental period.

<sup>b</sup>Each room with five pens, 6.7 ft<sup>2</sup>/pig (Trial 1) and 4.03 ft<sup>2</sup>/pig (Trials 2, 3, 4, and 5).

**Table 2. Composition and analysis of diets<sup>a</sup>.**

Item	Control	<i>Yucca schidigera</i>	Calcium chloride
<b>Ingredient, %</b>			
Corn	30.33	30.32	28.38
Soybean meal (46.5% CP)	20.50	20.50	20.50
Dried whey	30.00	30.00	30.00
Spray-dried plasma protein	6.00	6.00	6.00
Menhaden fishmeal	5.00	5.00	5.00
Corn oil	5.00	5.00	5.00
Dicalcium phosphate	1.55	1.55	1.55
Vitamin premix <sup>b</sup>	1.00	1.00	1.00
Trace mineral premix <sup>c</sup>	.20	.20	.20
Zinc oxide (72% zinc)	.42	.42	.42
<i>Yucca schidigera</i> extract <sup>d</sup>	—	.013	—
Calcium chloride <sup>e</sup>	—	—	1.95
<b>Nutrient composition</b>			
Crude protein <sup>f</sup> , %	23.20	23.30	22.90
Lysine <sup>g</sup> , %	1.58	1.58	1.58
Ca <sup>f</sup> , %	1.13	1.12	1.76
P <sup>f</sup> , %	.91	.98	.97
Na + K - Cl, mEq/kg <sup>h</sup>	345	345	-7

<sup>a</sup>As-fed basis.

<sup>b</sup>Supplied per kilogram of diet: retinyl acetate, 4,409 IU; cholecalciferol, 551 IU; all-rac- $\alpha$ -tocopheryl acetate, 22 IU; menadione (as menadione sodium bisulfite complex), 3.3 mg; riboflavin, 5.6 mg; d-pantothenic acid (as d-calcium pantothenate), 22 mg; niacin, 33 mg; choline (as choline chloride), 110 mg; cyanocobalamin, 22  $\mu$ g.

<sup>c</sup>Supplied (mg/kg of diet): Cu (as CuSO<sub>4</sub>•5H<sub>2</sub>O), 22; I (as Ca(IO<sub>3</sub>)<sub>2</sub>), 44;

Fe (as FeSO<sub>4</sub>•H<sub>2</sub>O), 220; Mn (as MnO), 44; Se (as Na<sub>2</sub>SeO<sub>3</sub>), 0.6; Zn (as ZnO), 220.

<sup>d</sup>*Yucca schidigera* extract (De-Odorase®, Alltech, Nicholasville, KY) added at the rate of 125 ppm (4 oz/ton).

<sup>e</sup>Calcium chloride (36.1% Ca; 63.9% Cl).

<sup>f</sup>Analyzed composition.

<sup>g</sup>Calculated composition.

<sup>h</sup>dEB (dietary electrolyte balance) = Na + K - Cl.

initial stress of weaning. For the next three weeks (Trials 1 and 2) and four weeks (Trials 3 to 5), three experimental diets were fed. All diets were formulated to meet or exceed the nutrient requirements of nursery pigs (NRC, 1998). Diets (Table 2) used were 1) Control, 2) Control plus 125 ppm of *Yucca schidigera* extract (De-Odorase, Alltech, Nicholasville, KY), and 3) Control plus 1.95% calcium chloride.

There were three identical pig nursery rooms. Each room had five pens and all pens had plastic-coated wire flooring; one nipple waterer; and one, three-hole, stainless steel feeder. Pigs had *ad libitum* access to feed and water throughout the trial. Heat lamps and comfort boards were provided during the first week after weaning.

In each room, relative humidity (maintained at 60%) and temperature



**Table 3. Growth performance, plasma urea concentration and ammonia concentration measured by diffusion tubes of pigs fed either a control diet, a diet with *Yucca schidigera*<sup>a</sup> extract, or calcium chloride diet<sup>b</sup> during the preliminary studies (Trials 1<sup>c</sup> and 2<sup>d</sup>).**

Item	Control	<i>Yucca schidigera</i>	Calcium chloride	SEM <sup>e</sup>	P-Value <sup>f</sup>
ADG, lb	.765 <sup>g</sup>	.765 <sup>g</sup>	.565 <sup>h</sup>	.019	.027
ADFI, lb	1.111	1.157	1.031	.043	.320
ADG/ADFI	1.511 <sup>g</sup>	1.452 <sup>g</sup>	1.166 <sup>h</sup>	.040	.045
Urea, mg/100 mL	35.68	35.59	29.35	1.200	.100
Aerial ammonia, ppm	8.00	5.60	7.30	2.028	.711

<sup>a</sup>*Yucca schidigera* extract (De-Odorase®, Alltech, Nicholasville, KY) added at the rate of 125 ppm.

<sup>b</sup>1.95% calcium chloride added.

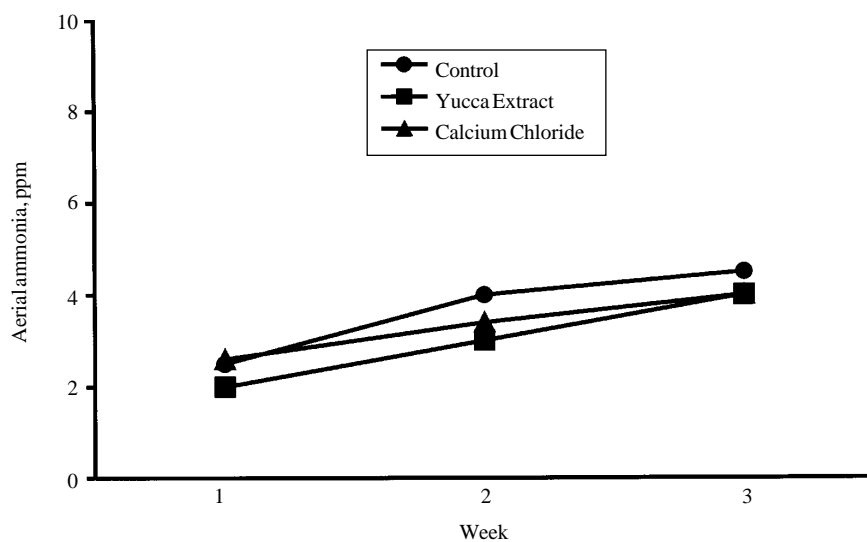
<sup>c</sup>Each room with five pens with six barrows per pen. Initial weight 11.4 lb; final weight 31.2 lb. 28-d experiment; 21-d experimental diets.

<sup>d</sup>Each room with five pens with ten pigs (six barrows and four gilts) per pen. Initial weight 6.6 lb; final weight 20.3 lb. 28-d experiment; 21-d experimental diets.

<sup>e</sup>Standard error of means.

<sup>f</sup>Significance of main effect.

<sup>g,h</sup>Within a row, means without a common superscript letter differ ( $P < .05$ ).



**Figure 1. Aerial ammonia concentrations measured by ammonia aspiration tubes (SEM=.16) in rooms with pigs fed a control, *Yucca schidigera* extract (De-Odorase), or calcium chloride diet (preliminary studies).**

(maintained at 77°F) were monitored continuously using temperature and humidity recorders. Airflow in the exhaust duct from each room (maintained at 920 ft<sup>3</sup>/min) was measured two times per day (8:00 am and 2:00 pm) using an air velocity meter. Aerial ammonia concentration was measured every day at 8:00 am by using Sensidyne aspiration tubes. Air was sampled in the center of the left and right sides of

the rooms approximately 3.3 ft above floor level. Ammonia was also measured using 8-hour Dräger diffusion tubes distributed throughout each room at approximately 1.6 ft above the floor three times during the last week of each trial. Five tubes were used per room to measure differences in ammonia concentration in different places in the rooms.

Feces and urine that collected

below the pens were allowed to accumulate throughout the trials. Manure (feces, urine, spilled feed and spilled drinking water) that drained from the pens was maintained in a collection pit located at the end of each room. These pits were emptied weekly because their capacity was limited. Water was not added when pits were emptied. Blood was collected from the jugular vein of each pig at the end of the trial to determine plasma urea concentration.

## Results

**Preliminary Studies:** There were no differences in ADG, ADFI, and ADG/ADFI of pigs fed the control diet and the diet containing *Yucca schidigera* extract diet (Table 3). However, there was a reduction in ADG and ADG/ADFI ( $P < .05$ ) of pigs fed the calcium chloride diet compared with pigs fed the other two diets. There were no differences in ADFI among pigs fed the three diets. There were no differences in plasma urea concentration among treatments (Table 3).

There was no effect of diet on aerial ammonia measured by either Sensidyne aspiration tubes (Figure 1) or Dräger diffusion tubes (Table 3). However, a tendency for increased aerial ammonia was observed in rooms with pigs fed the control diet compared with rooms in which pigs were fed the *Yucca schidigera* extract diet ( $P = .08$ ) and the calcium chloride diet ( $P = .10$ ). Aerial ammonia concentration increased as the experiment progressed ( $P < .001$ ) in all rooms.

**Major Study:** There were no differences in ADG, ADFI, and ADG/ADFI of pigs fed the control diet and the pigs fed the diet containing *Yucca schidigera* extract (Table 4). There were no differences in ADFI among pigs fed any of the three diets. There was a significant reduction in ADG and ADG/ADFI ( $P < .05$ ) of pigs fed the calcium chloride diet compared with pigs fed the other two diets. There were no differences in plasma urea concentration among treatments.

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There was no effect of diet on aerial ammonia measured by Dräger diffusion tubes during the final week of the experiment (Table 4). The aerial ammonia concentrations measured by Sensidyne aspiration tubes increased weekly ( $P < .001$ ) in all treatments (Figure 2). There was a diet x week ( $P < .001$ ) interaction, with a greater increase of aerial ammonia in rooms with pigs fed the control diet compared with the other rooms. Differences among treatments were evident during the third week ( $P = .07$ ) and clear during the fourth week ( $P < .001$ ), when ammonia concentration was 2.5 and 2.7 ppm higher in rooms with pigs fed the control diet compared with the concentration in rooms with pigs fed the yucca extract and the calcium chloride diets, respectively (Figure 2).

### Discussion

In this experiment, there was no effect of yucca extract additive on growth performance in nursery pigs. Lowering the dietary electrolyte balance with calcium chloride resulted in reduced ADG and ADG/ADFI compared with pigs fed the control or yucca extract diets. This was probably due to a metabolic acidosis produced by the increased plasma chloride, which is the mechanism by which calcium chloride generally decreases feed intake and weight gain. In this research, feed intake was reduced by 7% to 10% in pigs fed the calcium chloride versus the control diet in the preliminary studies, but this difference was not statistically significant.

Ammonia concentrations were relatively low, probably because of the small size of the pigs and the high ventilation rate in our research facility. The lower weight gain in pigs fed the calcium chloride diet may have been at least partly responsible for the decreased ammonia concentration in rooms in which pigs were fed this treatment.

Ammonia concentration measured by diffusion tubes was not different among the three rooms. However, lower

**Table 4. Growth performance, plasma urea concentration and ammonia concentration measured by diffusion tubes of pigs fed either a control diet, a diet with *Yucca schidigera*<sup>a</sup> extract, or calcium chloride diet<sup>b</sup> during the major study (Trials 3<sup>c</sup>, 4<sup>d</sup>, and 5<sup>e</sup>).**

Item	Control	<i>Yucca schidigera</i>	Calcium chloride	SEM <sup>f</sup>	P-Value <sup>g</sup>
ADG, lb	.968 <sup>h</sup>	.965 <sup>h</sup>	.732 <sup>i</sup>	.023	.028
ADFI, lb	1.364	1.339	1.229	.073	.456
ADG/ADFI	1.579 <sup>h</sup>	1.621 <sup>h</sup>	1.291 <sup>i</sup>	.041	.050
Urea, mg/100 mL	29.29	27.73	26.48	1.170	.400
Aerial ammonia, ppm	8.92	8.28	5.75	1.220	.348

<sup>a</sup>*Yucca schidigera* extract (De-Odorase®, Alltech, Nicholasville, KY) added at the rate of 125 ppm (4 oz/ton).

<sup>b</sup>1.95% calcium chloride added.

<sup>c</sup>Each room with five pens with ten pigs (seven barrows and three gilts) per pen. Initial weight 7.7 lb; final weight 33.44 lb, 35-d experiment; 28-d experimental diets.

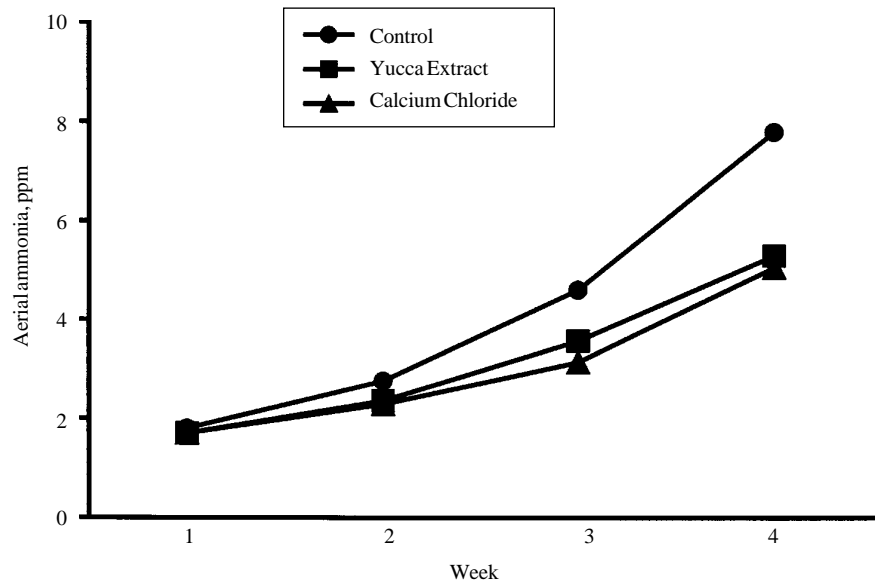
<sup>d</sup>Each room with five pens with ten pigs (six barrows and four gilts) per pen. Initial weight 13.0 lb; final weight 41.5 lb; 35-d experiment; 28-d experimental diets.

<sup>e</sup>Each room with five pens with ten pigs (five barrows and five gilts) per pen. Initial weight 10.5 lb; final weight 38.4 lb; 35-d experiment; 28-d experimental diets.

<sup>f</sup>Standard error of means.

<sup>g</sup>Significance of main effects.

<sup>h,i</sup>Within a row, means without a common superscript letter differ ( $P < 0.05$ ).



**Figure 2. Aerial ammonia concentrations measured by ammonia aspiration tubes (SEM=.54) in rooms with pigs fed a control, *Yucca schidigera* extract (De-Odorase), or calcium chloride diet (major study).**

concentrations were measured by aspiration tubes in rooms with pigs fed yucca extract or calcium chloride compared with the control diet. There was considerable variation in ammonia concentration among samples obtained from different locations in the rooms. Ammonia concentrations were highest when the tubes were placed over the

manure maintained below the pens. Lower concentrations of ammonia were measured when samples were taken from the right side of the room (few feces on the floor) compared with the left side (feces on the floor) or when measured over the collection pit.

In this study, manure collection pits were emptied weekly because the



capacity to store feces, urine, waste feed and spilled drinking water was limited. This may have limited aerial ammonia concentration. In spite of the relatively low concentration of aerial ammonia, these results show that *Yucca schidigera* extract and calcium chloride diets can be used to reduce ammonia concentration from nursery pig facilities. These effects were most evident during the third and fourth weeks of the major study.

Plasma urea concentration was not affected by diet. In the present study, crude protein levels and ADFI were similar among treatments. Apparently the changes in ammonia concentration caused by the dietary treatments were not reflected in changes in plasma urea.

### Conclusions

The results from these studies indicate that ammonia concentrations in nursery pig facilities can be reduced by using feed additives such as *Yucca schidigera* extract and calcium chloride. Aerial ammonia concentrations increased steadily as the trials progressed, but never reached excessive concentrations. However, under commercial conditions, where the air exchange rate is lower and the density of nursery pigs is greater than those used in this study, aerial ammonia concentrations may be higher. The different response of growth performance between pigs fed the calcium chloride diet and the pigs fed the control diet can be attributed to alterations in the dietary electrolyte balance in pigs fed calcium chloride. Further research is needed to determine the optimal concentration of this calcium salt that must be added to nursery diets to reduce ammonia concentration without reducing growth performance.

<sup>1</sup>Janeth J. Colina is a graduate student in animal science, Austin J. Lewis is a professor of animal science, Phillip S. Miller is an associate professor of animal science, and Robert L. Fischer is a graduate student and technician in animal science.

# Plasma Urea Concentrations of Pigs on Commercial Operations

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## Summary and Implications

*Research was conducted on commercial swine operations to determine whether plasma urea concentrations could be used as an indicator of the protein requirement of growing-finishing pigs. The research consisted of a 30-question survey and an on-farm visit to collect blood and feed samples. The survey included questions about genetics, nutrition, housing and health. Results showed that when plasma urea concentrations were analyzed across all phases of production, barrows had greater plasma urea concentrations than gilts. Plasma urea concentrations varied between the different phases of production, with nursery pigs having the lowest plasma urea concentrations, followed by growing and finishing pigs, respectively. An increase in dietary crude protein resulted in an increase of plasma urea in barrows and gilts in all phases of production. The comparison of dietary crude protein concentrations and age of the pigs at the time of blood collection indicates that the majority of the diets were over-formulated for crude protein. The effects of sex, crude protein, and phase of production on plasma urea concentrations in pigs raised on commercial operations were similar to those in a research setting. These results suggest that within an individual swine operation, plasma urea is a useful indicator of the protein requirement of growing-finishing pigs.*

## Introduction

The main goal of pork producers is to produce a high-quality product at the least cost. For producers to attain this goal and remain competitive in a

changing industry, they must keep an open mind about changes that will improve the efficiency of their operations. To operate an efficient swine enterprise, producers must stay informed about new technologies in the areas of genetics, nutrition, management practices, facilities, and disease management. Implementing new technology from any one of these areas, or in combination, may alter the nutrient requirements of pigs in the operation. To monitor the protein requirement of pigs on a regular basis, a quick and reliable indicator of a pig's protein requirement would be an effective diagnostic tool for the producer and (or) nutritionist. This type of diagnostic tool would enable producers to formulate diets that accurately provide a pig with its dietary protein requirement and allow pigs to achieve their genetic potential for lean growth. The net result of a more precise feeding program would be decreased costs, because of an increase in the efficiency of nutrient use by the pig.

Diets that supply crude protein in excess of the requirements for maintenance and protein accretion are inefficient because excess protein nitrogen is excreted in the urine in the form of urea. Pigs have little ability to store excess amino acids independent of muscle protein. Thus, amino acids in excess of the requirement are catabolized (used for energy or fat deposition), and the nitrogen ( $\text{NH}_3$ ) is converted to urea, causing in some instances a sharp rise in plasma urea concentrations. Researchers have reported that dietary lysine concentrations above the requirement result in an increase in plasma urea concentration in growing and finishing pigs. A similar plasma urea pattern has been observed in pigs when dietary crude protein is supplied in excess of the requirement. These data suggest that feeding crude protein

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