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# Responses of Barrows Consuming a Diet Formulated on an Ideal Protein Basis at Different Feeding Levels

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# Responses of Barrows Consuming a Diet Formulated on an Ideal Protein Basis at Different Feeding Levels

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**Summary and Implications**

*An experiment was carried out to evaluate the performance, nutrient digestibilities and plasma metabolites of barrows fed with a corn-soybean meal diet (CONTROL) or a diet formulated on an ideal protein basis (IDEAL; supplemented with crystalline lysine, threonine, tryptophan and methionine). Each diet was offered either on an ad libitum basis or at a feeding level of 90 or 80 percent of ad libitum feed intake. Averaged for the entire experimental period, barrows fed the CONTROL diet gained seven percent faster (P < .05) and were five percent more efficient (P < .01) than barrows fed the IDEAL diet. As the level of feed intake decreased, there was a decrease in daily gain (P < .01), but feed efficiency tended to be improved (P < .10) for barrows fed 90 percent of ad libitum. The apparent digestibilities of dry matter and energy were approximately three percent greater (P < .01) for barrows fed the IDEAL diet. Plasma urea concentrations were lower in barrows fed the IDEAL diet, regardless of feeding level; however, for barrows fed the CONTROL diet, the urea concentration was lower when the feeding level was 80 percent of ad libitum (diet x level, P < .01). Over time, the urea concentration declined in barrows fed the IDEAL diet (diet x time, P < .01). The concentrations of plasma glucose were lower in barrows fed the CONTROL diet (P < .01), were reduced with each reduction in the feeding level (P < .01), and were diminished over time throughout the experiment (P < .01). Plasma nonesterified fatty acid concentrations were lower in barrows fed the CONTROL diet at the beginning of Phase 2 (diet x time, P < .05). The reduction in daily gain observed with the IDEAL diet suggests a deficiency of other essential amino acid(s) may have limited the growth potential of these pigs or that the "ideal" pattern was not correct for the pigs used in this research. Results from this study will help to provide a basis for future studies to investigate the apparent reduction in performance sometimes observed in pigs consuming lower protein, amino acid-supplemented diets. We recognize the reduction in growth performance observed for the IDEAL diet may be offset by changes in body composition.*

**Introduction**

In the 1996 Nebraska Swine Report, the concept and application of ideal protein was introduced. In that report, it was found the performance of gilts fed a corn-soybean meal diet was similar to that of gilts consuming a diet formulated on an ideal protein basis (first four limiting amino acids). However, it was also reported that barrows fed a corn-soybean meal diet had better performance than barrows fed the diet formulated on an ideal protein basis. The 1997 Nebraska Swine Report described another experiment with ideal protein. In the 1997 research, the use of the ideal protein diet resulted in a reduction in aerial ammonia concentration.

An ideal amino acid pattern allowing optimal growth performance is essential to serve as a method to reduce nitrogen excretion from pig production units and to use patterns of amino acids in more precise ways to establish nutrient requirements. The present experiment was conducted to identify possible mechanisms responsible for the reduced productivity of barrows consuming a corn-soybean meal-amino acid supplemented diet. In addition, the effect of feed intake reductions (to simulate feed intake under commercial conditions) on the efficiency of diet utilization was also evaluated.

**Procedures**

Thirty-six crossbred barrows (Danbred®, USA, Inc.; Dorchester, NE) with an initial weight of 69 pounds were allotted to a randomized complete block experiment with a factorial arrangement of six treatments. Two dietary treatments were combined with three different levels of feed intake.

**Table 1. Diet composition (as-fed basis)**

| Item, % Diet | Phase 1[a] CONTROL[b] | Phase 1[a] IDEAL[b] | Phase 2[a] CONTROL | Phase 2[a] IDEAL |
|---|---|---|---|---|
| Corn | 74.34 | 84.51 | 79.80 | 89.93 |
| Soybean meal, 46.5% CP | 20.96 | 10.13 | 15.45 | 4.71 |
| Tallow | 2.00 | 2.00 | 2.00 | 2.00 |
| Dicalcium phosphate | 1.20 | 1.40 | 1.25 | 1.50 |
| Limestome | .40 | .40 | .40 | .34 |
| Salt | .30 | .30 | .30 | .30 |
| Vitamin mix | .70 | .70 | .70 | .70 |
| Trace mineral mix | .10 | .10 | .10 | .10 |
| L-lysine HCl | — | .33 | — | .33 |
| L-threonine | — | .08 | — | .06 |
| DL-methionine | — | .04 | — | .01 |
| L-tryptophan | — | .01 | — | .02 |
| Chemical composition | | | | |
| Crude protein, %[c] | 16.21 | 13.04 | 14.22 | 10.21 |
| Lysine, %[d] | .82 | .78 | .67 | .63 |
| Calcium, %[d] | .67 | .68 | .66 | .66 |
| Phosphorus, %[d] | .56 | .55 | .55 | .54 |
| Gross energy, Mcal/lb[c] | 1.82 | 1.79 | 1.80 | 1.80 |

[a]Phase 1 = 69 to 118 lb body weight; phase 2 = 118 to 181 lb body weight.
[b]CONTROL= corn-soybean meal diet; IDEAL= corn-soybean meal-amino acid supplemented diet.
[c]Analyzed.
[d]Calculated.

**Table 2. Total and true ileal digestible amino acid composition of the diets (as-fed basis)**

| Item, % Diet | Phase 1[a] CONTROL[b] | Phase 1[a] IDEAL[b] | Phase 2[a] CONTROL | Phase 2[a] IDEAL |
|---|---|---|---|---|
| Lysine | .82(.69)[c] | .78(.69) | .67(.56) | .63(.56) |
| Tryptophan | .20(.17) | .15(.13) | .17(.15) | .13(.11) |
| Threonine | .62(.52) | .56(.48) | .55(.46) | .47(.39) |
| Methionine + cysteine | .54(.48) | .50(.45) | .50(.44) | .43(.37) |

[a]Phase 1 = 69 to 118 lb body weight; phase 2 = 118 to 181 lb body weight.
[b]CONTROL= corn-soybean meal diet; IDEAL= corn-soybean meal-amino acid supplemented diet.
[c]Values in parentheses represent calculated true ileal digestible percentages.

The diets used in the experiment are presented in Table 1. Phase 1 diets were offered for 25 days, until pig weight was approximately 118 lb. Phase 2 diets were provided for the next 30 days, until pig weight was approximately 181 lb. In each phase, a corn-soybean meal (CONTROL) or a corn-soybean meal-amino acid supplemented (IDEAL) diet was fed. Eighteen pigs received each dietary treatment. Three subgroups of six pigs were formed within each dietary treatment and allotted to one of three feeding levels: 1) pigs had ad libitum access to their diet, 2) pigs were offered 90 percent or 3) pigs were offered 80 percent of the feed consumed by the pigs with ad libitum access to the diet. Pigs with ad libitum access to their diet had feed available continuously. Feeders from pigs in this group were weighed daily to calculate the feed to be offered to pigs allotted to the other two feeding levels for the next 24 hours.

In the IDEAL diets, the protein concentration was reduced approximately four percent from the CONTROL diet (16.2 to 13.0 percent, phase 1; 14.2 to 10.2 percent, phase 2). The four first limiting amino acids (lysine, threonine, methionine and tryptophan) were added as crystalline amino acids to the IDEAL diet to meet the lysine concentration of the CONTROL diet and provide an amino acid pattern (relative to lysine) similar to the ideal pattern developed at the University of Illinois. The concentration of lysine and the ratios used for the next three limiting amino acids were based on calculated true ileal digestible values (Table 2). In order to meet the objectives of the study, the CONTROL and IDEAL diets were formulated to be slightly below the requirements for lysine and other amino acids.

All pigs were individually penned in an environmentally controlled room. Pigs remained on the study for 55 days. Pigs had ad libitum access to water and were fed three times a day throughout the experiment (9:00, 13:00 and 17:00 hours). Pigs were weighed and blood samples were taken weekly. Plasma samples were analyzed for urea, glucose and nonesterified fatty acids (NEFA). The response of each of these metabolites versus week of the study was examined. During the third week of phase 2, .25 percent of chromic oxide ($Cr_2O_3$) was added to the diet as an indigestible marker. Fecal samples were collected from each barrow during three consecutive days to calculate the apparent digestibility of dry matter, crude protein and energy.

## Results and Discussion

The performance of barrows consuming the CONTROL and the IDEAL diets for phase 1, phase 2, and the overall period is presented in Table 3. During phase 1, the daily gain ($P < .05$) and the feed efficiency ($P < .01$) were six percent greater for pigs fed the CONTROL diet compared with pigs fed with the IDEAL diet. As the level of feed intake decreased there was a concomitant decrease in daily gain ($P < .01$). During phase 2, pigs fed the CONTROL diet gained eight percent more weight ($P < .05$) and consumed five percent more feed ($P < .10$) than pigs fed the IDEAL diet. As the level of feed intake was reduced from ad libitum to a 80 percent of ad libitum, there was a reduction in daily gain ($P < .01$), however feed efficiency was greater ($P < .05$) for pigs fed 90 and 80 percent of ad libitum. Averaged for the entire experimental period, pigs

(Continued on next page)

fed the CONTROL diet gained seven percent faster (P < .05) and were five percent more efficient (P < .01) than pigs fed the IDEAL diet. Similarly, as the level of feed intake decreased, there was a decrease in daily gain (P < .01), but feed efficiency tended to be greater (P < .10) for pigs fed 90 percent of ad libitum. Overall, these findings agree with previous results in which barrows fed a corn-soybean meal diet had better performance than barrows fed an ideal protein diet similar to the one used in this experiment. The reduction in daily gain observed for pigs fed the IDEAL diet may suggest either a deficiency in other essential amino acid(s) that may have limited the growth potential of these pigs, or that the "ideal" pattern is not ideal for the pigs used in this study.

The apparent digestibilities of dry matter and energy were approximately three percent greater (P < .01) in pigs fed the IDEAL diet; however, the improved efficiency of nutrient digestion was not reflected in the performance of pigs fed the IDEAL diet. The greater digestibility may have been because fecal samples were collected during phase 2, during which feed intake of pigs fed the CONTROL diet was about five percent greater than that of pigs fed the IDEAL diet. Generally, there is an inverse relationship between feed intake and digestibility.

Plasma urea, glucose and NEFA concentrations are presented in Figures 1, 2 and 3, respectively. Plasma urea concentrations were lower for pigs fed the IDEAL diet than for pigs fed the CONTROL diet, regardless of feeding level. Furthermore, for pigs fed the CONTROL diet, the urea concentration was lower for pigs fed with a feeding level of 80 percent, compared with pigs fed on an ad libitum basis or with a feeding level of 90 percent (diet x level, P < .01). Over time, the plasma urea concentrations changed little in pigs fed the CONTROL diet, whereas the urea concentration declined in pigs fed the IDEAL diet (diet x time, P < .01). An excess plasma urea concentration may be expected when dietary protein is increased or when a diet with a disproportion in the amino acid con-

**Table 3. Performance of barrows fed control corn-soybean meal and ideal protein diets at three different feeding levels**

| Item[a] | Diet | CONTROL[b] | | | IDEAL[b] | | | SEM[c] |
|---|---|---|---|---|---|---|---|---|
| | Level, % | 100 | 90 | 80 | 100 | 90 | 80 | |
| No. of pigs | | 6 | 6 | 6 | 6 | 6 | 6 | |
| Phase 1 | | | | | | | | |
| Initial wt., lb | | 69.24 | 69.16 | 70.12 | 69.13 | 69.09 | 68.94 | 0.756 |
| Final wt, lb[de] | | 126.62 | 120.04 | 113.73 | 121.66 | 116.26 | 111.53 | 1.702 |
| ADG, lb[de] | | 2.30 | 2.04 | 1.74 | 2.10 | 1.89 | 1.70 | .061 |
| ADFI, lb[e] | | 4.71 | 4.17 | 3.76 | 4.64 | 4.18 | 3.74 | .111 |
| ADG/ADFI[f] | | .49 | .49 | .46 | .45 | .45 | .45 | .010 |
| Phase 2 | | | | | | | | |
| Final wt., lb[de] | | 197.32 | 187.15 | 172.47 | 186.27 | 176.80 | 167.44 | 4.172 |
| ADG, lb[de] | | 2.36 | 2.24 | 1.96 | 2.15 | 2.02 | 1.86 | 0.097 |
| ADFI, lb[eh] | | 6.49 | 5.66 | 5.13 | 6.12 | 5.44 | 4.88 | 0.192 |
| ADG/ADFI[g] | | .36 | .40 | .38 | .35 | .37 | .38 | 0.009 |
| Overall | | | | | | | | |
| ADG, lb[de] | | 2.33 | 2.15 | 1.86 | 2.13 | 1.96 | 1.79 | 0.071 |
| ADFI, lb[e] | | 5.70 | 5.00 | 4.52 | 5.47 | 4.88 | 4.38 | 0.151 |
| ADG/ADFI[fi] | | .41 | .43 | .41 | .39 | .40 | .41 | 0.007 |

[a]ADG=average daily gain, ADFI= average daily feed intake, and ADG/ADFI= feed efficiency.
[b]CONTROL= corn-soybean meal diet; IDEAL= corn-soybean meal-amino acid supplemented diet.
[c]SEM= Standard error of the mean.
[d]Diet effect, P < .05.
[e]Level effect, P < .01.
[f]Diet effect, P < .01.
[g]Level effect, P < .05.
[h]Diet effect, P < .10.
[i]Level effect, P < .10.

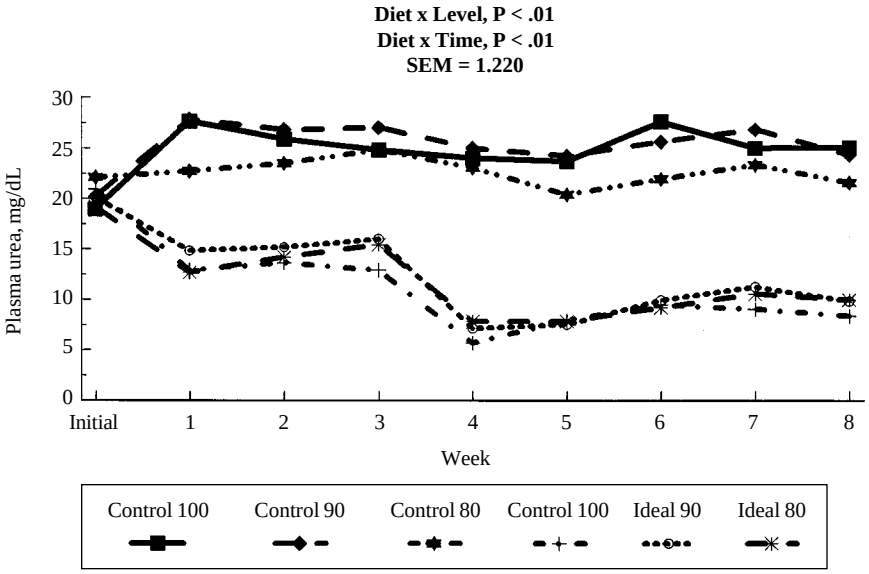


**Figure 1. Plasma urea concentration in barrows fed a corn-soybean meal (CONTROL) or a corn-soybean meal-amino supplemented (IDEAL) diet at three feeding levels.**

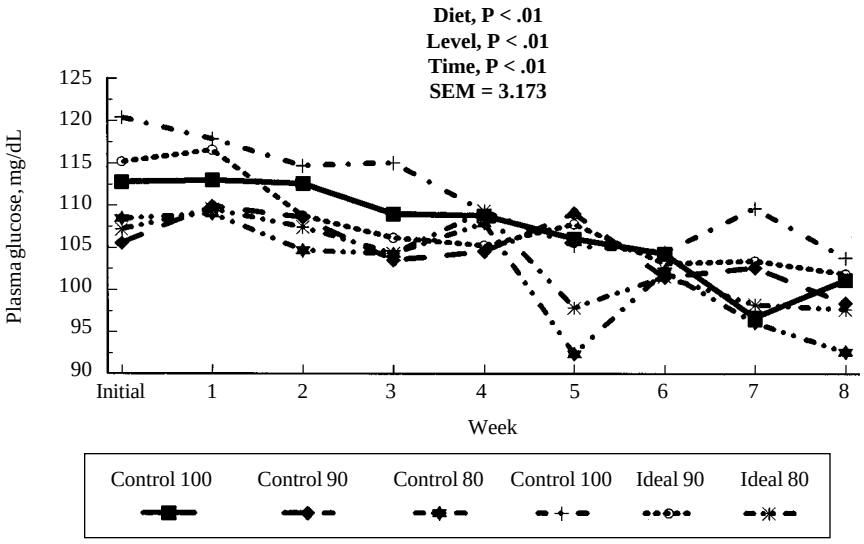


**Figure 2. Plasma glucose concentration in barrows fed a corn-soybean meal (CONTROL) or a corn-soybean meal-amino supplemented (IDEAL) diet at three feeding levels.**

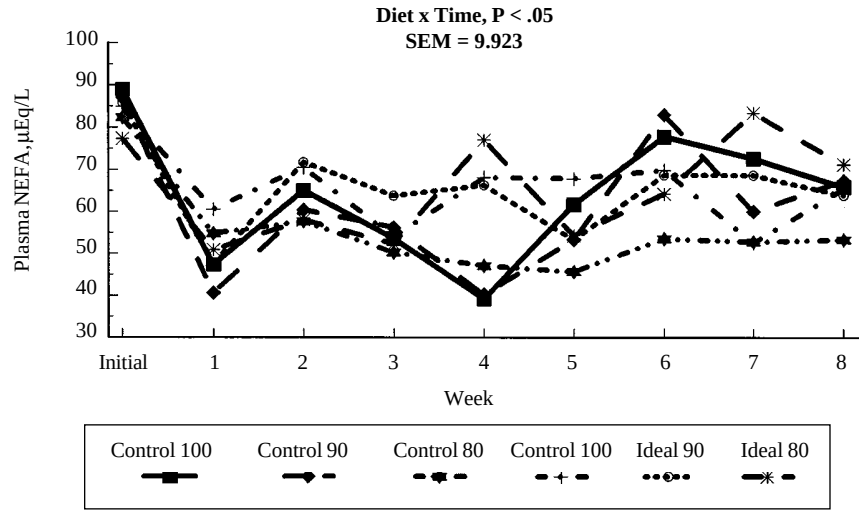


**Figure 3. Plasma NEFA concentration in barrows fed a corn-soybean meal (CONTROL) or a corn-soybean meal-amino supplemented (IDEAL) diet at three feeding levels.**

**Table 4. Nutrient digestibilities (percent) in barrows fed control corn-soybean meal and ideal protein diets at three different feeding levels**

| | Diet | CONTROL[a] | | | IDEAL[a] | | | |
|---|---|---|---|---|---|---|---|---|
| Item | Level, % | 100 | 90 | 80 | 100 | 90 | 80 | SEM[b] |
| No. of pigs | | 6 | 6 | 6 | 6 | 6 | 6 | |
| Dry matter[c] | | 89.05 | 89.63 | 88.79 | 91.13 | 91.95 | 91.92 | 0.536 |
| Crude protein | | 83.49 | 84.29 | 82.91 | 82.69 | 83.03 | 82.60 | 0.985 |
| Energy[c] | | 86.97 | 88.47 | 88.04 | 89.66 | 91.42 | 91.01 | 0.826 |

[a]CONTROL= corn-soybean meal diet; IDEAL= corn-soybean meal-amino acid supplemented diet.
[b]SEM= Standard error of the mean.
[c]Diet effect, P < .01.

centrations is consumed. The lower plasma urea concentrations in pigs fed the IDEAL diet may reflect both the reductions in dietary protein and that the amino acid pattern was better suited to meet the requirements for growth. Also, the lower plasma urea concentrations of pigs fed the CONTROL diet at a feeding level of 80 percent may reflect the reduction in feed intake and(or) an improved utilization of dietary amino acids compared to pigs having ad libitum access to feed or fed with a feeding level of 90 percent.

The concentrations of plasma glucose were lower in pigs fed the CONTROL diet (P < .01), were reduced as the feeding level was reduced (P < .01) and were diminished over time throughout the experiment (P < .01). Plasma NEFA concentrations were lower in pigs fed the CONTROL diet at the beginning of phase 2 (diet x time, P < .05). The physiological significance of elevated plasma glucose and NEFA concentrations in pigs fed with the IDEAL diet is unknown.

## Conclusions

Regardless of feeding level, growth performance and plasma urea concentrations were reduced in barrows fed a diet formulated on an ideal protein basis. The physiological significance of elevated glucose and NEFA concentrations in pigs consuming the IDEAL diet is unknown. The reduction in daily gain observed with the IDEAL diet may suggest a deficiency of other essential amino acid(s) that may have limited the growth potential of these pigs or that the "ideal" pattern was not correct for the pigs used in this research.

[1]Sergio Gomez is a graduate student, Phillip S. Miller is an associate professor, Austin J. Lewis is a professor, and Hsin-Yi Chen is a research technologist, in the Department of Animal Science, University of Nebraska, Lincoln.