EVALUATION OF SWINE DIET FORMULATION BASED ON AMINO ACID DIGESTIBILITY ESTIMATES[1]

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ABSTRACT - Three experiments were carried out to test the hypothesis that formulation of diets using true amino acid digestibility (TAAD) values for various alternative ingredients (AI) will result in similar performance to that achieved with a corn-soybean meal based diet. The TAAD values were obtained by swine ileal (I) and precision-fed (PF) rooster methods. A control corn-soy (C) diet provided the basal amino acid composition for use in the formulation of the AI diets. Additional diets with higher amino acid levels were prepared using ileal (ID) and precision-fed (DPF) digestibility data in formulation. Average daily gain (ADG) and feed intake (ADFI) were significantly higher ($P \leq .01$) when pigs were fed the C diet than when fed either the I or PF diets. Feeding diets ID and DPF resulted in higher ($P \leq .01$) ADG and ADFI than diet I and PF respectively. Pair feeding the C and AI diets produced same performance indicating that another factor may be related with intake of diets. It was concluded that formulation of diets using AI substituting soybean meal to levels of digestible amino acids equal to soybean meal-based diets may not give the same performance.

Index terms: protein, feeding, least-cost diets, digestion.

AVALIAÇÃO DE DIETAS PARA SUÍNOS FORMULADAS COM BASE NAS ESTIMATIVAS DE DIGESTIBILIDADE DE AMINOÁCIDOS

RESUMO - Três experimentos foram conduzidos para testar a hipótese de que dietas formuladas usando valores da digestibilidade verdadeira dos aminoácidos (DVAA) de ingredientes alternativos (IA) resultam em desempenho similar ao obtido com dietas à base de milho e farelo de soja (MFS). A DVAA foi obtida com os métodos ileal em suínos (I) e alimentação precisa em galos (AP). A dieta controle (C), com MFS forneceu a composição basal de aminoácidos para formular as dietas com IA. Dietas com níveis superiores de aminoácidos foram formuladas usando dados de digestibilidade ileal (DI) e alimentação precisa (DAP). Suínos alimentados com a dieta C tiveram ganhos diários médios (GDM) e consumo de alimentos diário médio (CADM) significativamente maiores ($P<0,01$) do que quando alimentados com as dietas DI ou DAP. Alimentando com dietas DI ou DAP resultou em maiores GDM e CADM, do que com dietas I e AP, respectivamente. A alimentação pareada das dietas C ou com IA produziu semelhante desempenho indicando que outro fator pode estar relacionado ao consumo. Conclui-se que a formulação de dietas com IA, com substituição total do farelo de soja, para níveis de aminoácidos digestíveis iguais ao de dietas com MFS, pode não proporcionar o mesmo desempenho dos suínos.

Termos para indexação: proteína, alimentação, dietas de custo-mínimo, digestão.

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INTRODUCTION

There have been a great number of experiments conducted to determine ingredient digestibility; most involving swine ileal and precision-fed rooster procedures (Easter, 1972; Sauer et al., 1977; Likuski & Dorrell, 1978; Sibbald, 1979; Tanksley Junior et al., 1981; Taverner et al., 1981; Just et al., 1985; Parsons, 1985; Partridge et al., 1987). However, according to Sauer & Ozimek (1986), few studies have been conducted to address the actual concern in the feed industry of whether or not it is advantageous to formulate diets based on digestible instead of total amino acid content of feed ingredients. A recent paper (Albino et al., 1992) was published on this subject using birds and the results show that there was positive response to the concept of formulating based on amino acid digestibility. In swine there is scarce information on this regard. Therefore the two growth experiments were conducted to test the hypothesis that diets formulated with different ingredients, but to the same concentrations of digestible amino acids, will support equal growth performance by growing pigs. In a third growth experiment, a pair feeding procedure was used to test the hypothesis that performance differences observed in the first two experiments were due to variations in feed intake.

MATERIAL AND METHODS

Three growth experiments were conducted employing pigs derived from a rotational crossbreeding system involving Hampshire, Yorkshire and Landrace breeds. Pigs were randomly assigned to treatment from outcome groups formed on the basis of litter, sex and weight. All experiments were conducted in an environmentally-regulated room. Temperature was set to 23ºC, and together with ventilation, was automatically controlled. Pigs were housed in partially slotted-floor pens each equipped with a nipple drinker and a self-feeder. The weights of the animals and the feeders were recorded at the beginning and at 14-day intervals in the *ad libitum* feeding experiments.

Experiment 1

Each of the five treatments had six replicates with four pigs per replicate. The average initial weight was 20.7 ± .2 kg. Pigs were fed the treatment diets for a period of 56 days. The swine were housed in a room with pens measuring 1.8 m by 2.7 m. The treatment diets, presented in Table 1, were calculated using the previous estimates of amino acid digestibilities (Bellaver, 1989). Feed and water were furnished *ad libitum*. The control diet was based on corn and soybean meal and was formulated to be marginally deficient in total lysine suggested by the National Research Council (1979) for growing pigs. In this manner, it was expected that the small changes in amino acid content of the diets would be reflected in pig performance (Tanksley Junior & Knabe, 1984). All diets were formulated to have similar levels of nitrogen, energy, acid detergent fiber, calcium and phosphorus. The diets used in the experiment are outlined below.

Diet 1 served as the control and was formulated with corn and soybean meal. All remaining diets were formulated using either ileal or precision-fed rooster digestibility values for the six alternative ingredients. In diet 2, ileal values were used to formulate to similar digestible lysine, threonine, methionine plus cystine and tryptophan values as diet 1. Diet 3 was similar, except that precision-fed rooster values were used. In diet 4 and 5 more amino acids were added to diets 2 and 3 to test the hypothesis that any depression in growth observed when pigs were fed diets 2 and 3 was due to overestimation of amino acid digestibilities in the alternative ingredients. The extra amino acids values were calculated to be similar to the amino acids provided in a 16% crude protein corn and soybean meal diet.

TABLE 1. Percentage composition of diets (Experiment 1)[1].

Ingredient	Low[2] aminoacid level			High[3] aminoacid level	
	Control	Ileal	Rooster	Ileal	Rooster
Corn	82.07	80.38	80.65	79.93	80.44
Soybean meal	13.87				
Poultry by-product		6.26	6.52	5.87	6.33
Cottonseed meal		5.00	5.00	5.00	5.00
Wheat bran		5.00	5.00	5.00	5.00
Soybean oil		1.33	1.08	1.72	1.25
Solka-Floc[4]	1.28			0.03	
Limestone	.78	.65	.64	.67	.65
Dicalcium phosphate	1.32	.47	.43	.52	.46
Mineral mixture[5]	.35	.35	.35	.35	.35
Vitamin mixture[5]	.10	.10	.10	.10	.10
L-Lysine.HCl		.15		.33	.17
DL-Methionine		.02		.08	
L-Threonine		.04		.12	
L-Tryptophan		.02		.05	.02
Tylan[6]	.23	.23	.23	.23	.23
Calculated composition (as fed, %)					
Crude protein	13.00	13.00	13.00	13.00	13.00
M.E. (kcal/kg)	3254	3254	3254	3254	3254
ADF	4.1	4.2	4.2	4.1	4.2
Calcium	.60	.60	.60	.60	.60
Phosphorus	.50	.50	.50	.50	.50
Available phosphorus	.31	.31	.31	.31	.31
Total					

Lysine	.62	.66	.56	.77	.68
Met + Cys	.53	.55	.53	.59	.53
Threonine	.47	.50	.47	.56	.47
Tryptophan	.14	.14	.13	.17	.14
Digestible					
Lysine	.48	.48	.49	.59	.59
Met + Cys	.47	.47	.51	.51	.51
Threonine	.37	.37	.45	.43	.44
Tryptophan	.09	.09	.11	.12	.12

[1] Percent composition in a 90% dry matter; ileal and rooster digestibility estimates were based on swine ileal sampling and precision-fed rooster excreta collection, respectively (Bellaver, 1989).
[2] Low = formulated to provide the estimated digestible amino acid level for lysine, methionine plus cysteine, threonine, tryptophan provided in a 13% crude protein corn and soybean meal diet.
[3] High = as low but amino acids in the diets would be of 16% crude protein.
[4] Cellulose, James River Co. Berlin, NH.
[5] Trace minerals, sodium chloride and vitamins supplemented with premixes to provide National Research Council (1979) recommendations.
[6] Provided 11 ppm of Tylosin.

Experiment 2

This experiment was conducted to verify the results of experiment 1 using different ingredient combinations. One hundred and twenty pigs were allotted to five treatments. Each treatment had six replicates and four pigs per replicate. The average initial weight was 26.7 $\pm$ .3 kg. Pigs continued on the experiment for 42 days and reached a final average weight of 53.1 kg.

The swine were housed in a room with pens measuring 1.8 m by 2.7 m. Feed and water were furnished *ad libitum* and the diets, presented in Table 2, were calculated using the ileal estimates of amino acid digestibility. The control diet was based on corn and soybean meal and formulated to be marginally deficient in the total lysine suggested by the the National Research Council (1988) for growing pigs. In this manner, the small changes in amino acid content of the diets would reflect the pigs' performance (Tanksley Junior & Knabe, 1984). All diets were formulated to have similar levels of nitrogen, energy, fiber, calcium and phosphorus. However, diet 4 was calculated to equal digestible lysine as on control diet and due this there was a large addition of poultry by-product in the diet. As a result, calcium and phosphorus, could not be balanced as the control diet for these minerals.

TABLE 2. Percentage composition of diets (Experiment 2)[1].

Number	Diet number[2]				
	1	2	3	4	5
Corn	84.15	81.99	81.17	71.95	81.73
Soybean meal	10.89				
Poultry by-product		4.73	4.19	15.71	
Meat and bone meal					5.30
Cottonseed meal		5.00	5.00	5.00	5.00
Wheat bran		5.00	5.00	5.00	5.00
Soybean oil	.35	1.15	1.81	1.66	1.58
Solka-Floc[3]	1.39	.06	.14		.19
Limestone	.78	.72	.74		
Dicalcium phosphate	1.4	.67	.74		
Mineral mixture[4]	.35	.35	.35	.35	.35
Vitamin mixture[4]	.10	.10	.10	.10	.10
L-Lysine.HCl	.28		.41		.40
L-Threonine	.06		.09		.09
L-Tryptophan	.02		.03		.03
Tylan[5]	.23	.23	.23	.23	.23
Calculated composition :					
Crude protein (%)	12.00	12.00	12.00	18.00	12.00
M.E. (kcal/kg)	3254	3254	3254	3254	3254
ADF	4.0	4.1	4.1	4.8	4.2
Calcium	.60	.60	.60	.68	.60
Phosphorus	.50	.50	.50	.63	.50
Available phosphorus	.31	.31	.31	.43	.31
Total					

Lysine	.73	.50	.77	.85	.77
Threonine	.47	.42	.50	.68	.50
Tryptophan	.14	.12	.14	.16	.14
Digestible					
Lysine	.60	.33	.60	.60	.60
Threonine	.38	.31	.38	.50	.38
Tryptophan	.10	.07	.10	.10	.10

[1] Percent composition in a 90% dry matter.
[2] Amino acid source: diet 1, soybean meal; diet 2 and 4, poultry by-product (PBP); diet 3, PBP plus crystalline amino acid; diet 5, meat and bone meal plus crystalline amino acids.
[3] Cellulose, James River Co. Berlin, NH.
[4] Trace minerals, sodium chloride and vitamins supplemented with premixes to provide National Research Council(1988) recommendations.
[5] Provided 11 ppm of Tylosin.

Diet one was based on corn and soybean meal with 12% crude protein, i.e. 80% of the the National Research Council (1988). In diet 2 alternative ingredients were used to provide a level of crude protein equal to diet 1. It was expected that this would depress performance. Diet 3 was formulated by first, calculating the ileal digestible content of lysine, tryptophan, threonine and methionine plus cystine and then adding each of these amino acids in the crystalline form until the level of digestible amino acid in diet 1 was reached. Diet 4 was formulated to provide equal or higher levels of digestible amino acids than in diet 1. In diet 4 only natural ingredients were used. Finally, diet 5 was developed to provide the same minimum digestible level of the four amino acids as diets 1, 3, and 4 except that meat and bone meal was used as an ingredient instead of poultry by-product.

Experiment 3

Twenty pigs averaging 39.4 ± .8 kg were allotted to two treatments. The experimental animals were maintained in individual pens measuring .90 m x 2.7 m each with an individual feeder. The pigs were allowed four days to adapt to the pens and to feeding regime of three meals per day, fed at 8 hour intervals. The feed allowance for the pair-fed pigs was based on the the National Research Council (1987) feed intake prediction equations. A corn and soybean meal diet with 16% crude protein was used during the adaptation period and diets 1 and 3 from experiment 2 were fed during the seven day experimental period.

The pigs were weighed at the beginning and at end of the experimental period. Feed consumption was recorded daily. In addition, heparinized blood samples were collected 3.5 hours postprandially from all pigs by jugular venipuncture on days 1, 5 and 7 of the experimental period. Plasma was separated by centrifugation at 3000 rpm for 15 minutes, stored at -10^0C until analysis for plasma urea nitrogen - PUN (Sigma Diagnostics, St. Louis, MO, Kit 640).

Statistical analysis

Animal performance data were analyzed using a complete randomized block design (Neter et al., 1985), as shown in the following model, and the analysis was facilitated with use of the SAS package (SAS Institute, 1985). Model: $Y_{ijk} = u + T_i + B_j + e_{ijk}$; where, Y_{ijk} = response of k^{th} pen to the i^{th} treatment in the j^{th} block; u = the overall response mean; T_i = effect of the i^{th} treatment; B_j = effect of j^{th} block and e_{ijk} = the random error. The hypotheses were tested by contrast comparisons.

RESULTS AND DISCUSSION

Experiment 1

Pig performance data are shown in Table 3. Growth and growth efficiency of pigs fed diets 2 and 3 were significantly ($P \leq .01$) inferior to those fed the control diet 1. However, when the level of lysine, threonine and tryptophan of the diets 2 and 3 were increased (diets 4 and 5), there was a positive response ($P \leq .01$). This demonstrates that the growth reduction in pigs fed diets formulated to be equal in digestible amino acids to diet 1 was still limited by the level of amino acids. Lysine was calculated to be the most limiting amino acid in diets 2 and 3 as it was in diet 1 based in corn and soybean meal. Digestible lysine intake (DLI) in grams per day followed the same pattern of response as average daily gain (ADG) helping to explain the response of ADG. However, when the ratio of the gain (G) per DLI was calculated (G/DLI) it was found that all diets were inefficient in comparison with the control diet.

TABLE 3. Growth performance of growing pigs (20.7 to 53.6 kg) fed diets formulated on the basis of swine ileal or precision-fed digestibility estimates[1].

Variable	Low[2] amino acid			High[3] amino acid		SE
	Control	Ileal	Rooster	Ileal	Rooster	
Initial weight (kg)	20.7	21.1	20.6	20.7	20.5	.19
ADG [4] (kg)	.69	.57	.42	.66	.59	.018
ADFI [5] (kg)	1.95	1.76	1.47	1.82	1.76	.047
G/F[4]	.35	.33	.29	.36	.34	.004
DLI (g/d) [6]	9.36	8.45	7.21	10.74	10.36	.252
G/DLI (g/g) [7]	73.41	67.71	58.53	61.72	57.02	.844

[1] Ileal and rooster digestibility estimates were based on swine ileal sampling and precision-fed rooster excreta collection respectively (Bellaver, 1989).
[2] Low = formulated to provide the estimated digestible amino acid level for lysine, methionine plus cysteine, threonine, tryptophan provided in a 13% crude protein corn and soybean meal diet.
[3] High = as low but amino acids in the diet would be of 16% crude protein diet.
[4] ADG = average daily gain; G/F = gain to feed ratio; significant contrasts 1 vs. 2, 1 vs. 3, 2 vs. 4 and 3 vs. 5 ($P \leq .01$).
[5] ADFI = average daily feed intake; significant contrasts 1 vs. 2, 1 vs. 3, and 3 vs. 5 ($P \leq .01$).
[6] DLI = digestible lysine intake in grams per day; significant contrasts 1 vs. 2 ($P \leq .05$), and 1 vs. 3, 2 vs. 4 and 3 vs. 5($P \leq .01$).
[7] G/DLI = gain per gram of digestible lysine intake (wt/wt); significant contrasts 1 vs. 2, 1 vs. 3 and 2 vs. 4 ($P \leq .01$).

An examination of the data shows that there was a decrease ($P \leq .01$) in intake for diets 2 and 3 in comparison to the control diet. In a similar experiment Tanksley Junior & Knabe (1984) also reported reduction in feed intake when digestible amino acids estimates were used to formulate cottonseed meal--based diets to have similar digestible lysine values as a soybean meal-based diet. This is in contrast to the work by Batterham (1987) wherein similar carcass gain and feed conversion values were found when diets were formulated with barley-cottonseed meal to have same available lysine content as in a barley-soybean meal diet. In the Batterham (1987) work feed intake was restricted. Therefore, pigs fed the barley-soybean meal diet did not have an opportunity to completely express their appetite response.

Lower intake seen with diets 2 and 3 may have been a consequence of overestimation of actual digestibility values by the methods used (Bellaver, 1989). Black & Davies (1987) suggested that lysine availability, measured by ileal digestibility method, can be overestimated by as much as 25%. This is based on predictions from the AUSPIG growth model and has not been tested experimentally.

Four factors may explain the differences in intake. They are the palatability of the diets, the distention of the gastro-intestinal tract, the production of toxic amines in the gut and associative effects among ingredients. The effects of taste (Houpt, 1984; Curtis, 1986) and physical distention of the gastro-intestinal tract (Houpt, 1984) on feed intake have been discussed elsewhere. Fiber also can be a problem in this type of experiment. In the present growth experiments, an attempt was made to equalize the fiber level of the diets with powdered cellulose. However, this procedure for fiber correction does not balance the intake of different fractions of fiber. Schneeman (1987) reported that soluble fiber, i.e. hemicellulose, has higher water-holding capacity than the insoluble fractions thus contributing to an increase in the fecal bulk and gastric distention. Moreover, fiber from straw produces much more liquid secretions than powdered cellulose (Zebrowska, 1985). The increase in secretions in the gut may modify gut fill and cause differences in intake.

Diets formulated with wheat bran and cottonseed meal had 2.8% and .5% more hemicellulose and lignin respectively than the control diet. It was stated above that hemicellulose has higher water-holding capacity than cellulose. Lignin content of the diet appears also to be related to lower amino acid digestibility due to hydrophobic bonding with amino acids (Blair et al., 1983).

The role of toxic amines in feed intake can not be discounted as a factor in the present experiment. According to Bergner (1981), undigested proteins are hydrolyzed in the large intestine to a large number of products including tyramine and tryptamine which are derivatives of tyrosine and tryptophan. These amines can saturate the hypothalamus, therefore reducing the feed intake.

The last point in this discussion concerns additivity of amino acid contributions from different feed ingredients. It is generally assumed that the digestible amino acids will be linearly additive when combined in a complex diet. However, there is information that fibrous feeds, particularly, or feeds containing anti-nutritive substances, will moderate additivity due to associative effects. Others, however, have reported complete additivity among ingredients (Sauer et al., 1983; Imbeah et al., 1987; Partridge et al., 1987). The conclusion from the Sauer et al. (1983) experiment is questionable due to large differences in digestible amino acids content between treatments that should have been formulated to be equal.

Associative effects of ingredients may be a function of fiber composition of the ingredients. For instance, feeding with wheat straw diet depresses crude protein and amino acid digestibility more than a diet formulated to a similar fiber level with powdered cellulose (Huisman et al., 1985; Maenhout et al., 1987). Also, diets made with wheat straw increased output of protein in pancreatic juice (Zebrowska, 1985; Maenhout et al., 1987) in comparison to diets made with powdered cellulose and fed at a similar protein content. The pancreatic secretion was doubled ($P \leq .01$) (Zebrowska, 1985).

The failure to restore performance to the level of the control diet by addition of amino acids to diets 4 and 5 was not unexpected, although the levels of addition should have exceeded the need for correction of any amino acid deficiency. Crystalline amino acids can be used effectively to correct deficiencies in reduced-protein, corn-soybean meal-based diets (Easter & Baker, 1980; Russell et al., 1983; Russell et al., 1987). It is likely that factors in the feedstuffs, other than amino acid content, affected the performance response in this experiment.

The failure to achieve equal growth performance among pigs fed diets formulated to equal concentrations of digestible amino acids has been demonstrated previously by Tanksley Junior & Knabe (1984). They reported that pigs fed diets containing cottonseed meal failed to reach the performance of pigs fed a soybean meal-based diet even when lysine was supplemented to an equal digestible amino acid level. In that experiment however, formulation of diets on the basis of digestible lysine resulted in performance that was closer to the control diet than if diets had been formulated on a crude protein or total lysine basis.

Experiment 2

The performance of the pigs used in this experiment is shown in Table 4. Gain by the pigs fed the control diet was greater than for those fed diets 3 ($P \leq .01$), 4 ($P=.071$), and 5 ($P \leq .05$). Intake of the control diet was higher than for diet 3 ($P=.0742$) and diet 5 ($P=.0875$). Also, daily intake for diet 3 was greater ($P=.0546$) than for diet 2. Contrast comparisons for the feed efficiency revealed that diet 3 was significantly different from both 1 ($P \leq .05$) and 2 ($P \leq .01$). Digestible lysine intake (DLI) in grams per day in diet 2 was significantly lower ($P \leq .01$) than all the other diets. In contrast the efficiency of lysine conversion in gain (G/DLI) was higher than the other diets ($P \leq .01$). Except for diet 2, the other diets consumed the same amount of digestible lysine but were inefficient in comparison with corn-soybean meal diet regarding to G/DLI.

TABLE 4. Growth performance of growing pigs (26.7 to 53.1 kg) fed diets formulated on the basis of swine ileal digestibility estimates.

Variable	Diet number[1]					SE
	1	2	3	4	5	
Crude protein (%)	12.00	12.00	12.00	18.00	12.00	
Initial weight (kg)	26.87	26.97	26.48	26.27	26.96	.28
ADG [2] (kg)	.74	.42	.64	.68	.66	.022
ADFI [3] (kg)	2.05	1.69	1.87	1.91	1.88	.065
G/F [4]	.36	.25	.34	.36	.35	.006
DLI (g/d) [5]	12.28	5.56	11.24	11.48	11.29	.359
G/DLI (g/g) [6]	60.28	75.74	57.08	59.31	58.79	1.067

[1] Amino acid source: diet 1, soybean meal; diet 2 and 4, poultry by-product (PBP); diet 3, PBP plus crystalline amino acid; diet 5, meat and bone meal plus crystalline amino acids.

[2] ADG = average daily gain; significant contrasts 1 vs. 3 and 2 vs. 3 (P≤.01);1 vs. 4 P=.071) and 1 vs. 5 (P≤.05).
[3] ADFI = average daily feed intake; significant contrasts 1 vs. 3 (P=.0742); 1 vs. 5 (P=.0875) and 2 vs. 3 (P=.0546).
[4] G/F = gain to feed ratio; significant contrasts 1 vs. 3 (P≤.05) and 2 vs. 3 (P≤.01).
[5] DLI = digestible lysine intake in grams per day; significant contrast 2 vs. 3 (P≤.01).
[6] G/DLI = gain per gram of digestible lysine intake (wt/wt); significant contrasts 1 vs. 3 (P=.047) and 2 vs. 3 (P≤.01).

In this experiment the control diet was calculated to meet 80% of the National Research Council (1988) requirement for total lysine, tryptophan, threonine and methionine plus cysteine. The available amino acid requirements for pigs are not yet established. As the goal of this work was to compare performance of pigs fed diets formulated on the basis of digestible amino acids it was important to work in a range below the requirement to ensure that differences in amino acid utilization could be measured as differences in growth. Tanksley Junior & Knabe (1984) also worked at slightly deficient levels in a similar study. The value of 80% was selected on the assumption that this would be below the point of maximal response on an amino acid response curve.

This experiment once again indicated that digestible amino acid correction alone did not result in performance similar to the positive control diet. Diet 2 was made equal in crude protein to diet 1 (control corn-soybean meal diet) using a variety of alternative ingredients to replace soybean meal. Amino acid content was ignored and, as expected, growth performance was significantly reduced. Swine ileal digestibility values and supplemental crystalline amino acids were used to make diet 3 equal in estimated digestible lysine, threonine, tryptophan and methionine plus cysteine, to diet 1. Growth was depressed, apparently as a result of depressed feed intake. This suggests that either the digestibility estimates were in error or that some other factor associated with the feedstuff caused the inferior performance as discussed above.

In diet 4, poultry by-product meal was used to provide additional amino acids needed to bring the digestible amino acid level to that of diet 1. In diet 5, meat and bone meal and crystalline amino acids were used for that purpose. As before, performance was inferior to the corn-soybean meal-based control (diet 1).

Experiment 3

Because feed intake appeared as a variable factor in both experiment 1 and 2, experiment 3 was designed to measure the response of pigs to equal intakes of two diets (diets 1 and 3 from Table 2) formulated to levels of digestible lysine, threonine, tryptophan and methionine plus cystine, but with different ingredients. The results of this experiment are shown in Table 5. When fed equal amounts, growth rate and feed efficiency did not differ (P≥.05). More importantly plasma urea nitrogen (PUN) was not significantly (P≥.01) affected by the treatments. Under equalized intake of the control, an increase in PUN concentration in diet 2 would be indicative of an increased rate of protein catabolism. As this was not found, it is concluded that both diets provided similar (P≥.01) amounts of absorbed protein for metabolism. Plasma urea nitrogen has been used to estimate the extent of deamination and wastage of feed nitrogen (Evans & Witty, 1978). Thus, the difference in feed intake between the control and the alternative ingredient diets seems to be related to other factor (previously discussed) than to the inaccurate estimate of amino acid digestibility.

TABLE 5. Plasma urea nitrogen (PUN), average daily gain (ADG), average feed intake (ADFI) and gain to feed ratio (G/F) of pair-fed pigs[1].

Diet	PUN[2] (mg/dL)	PUN[3] (mg/dL)	ADG (kg)	ADFI (kg)	G/F
Corn-soybean meal	10.37	5.94	.64	2.11	.30
Alternative ingredients[4]	11.12	5.73	.61	2.11	.29
SE[5]	.4	.26	.02		.008

[1] Average initial weight was 39.4 ± .8 kg with 10 pigs per treatment.
[2] PUN at beginning of pair feeding.
[3] PUN average of days five and seven.

[4] Alternative ingredients were used plus crystalline lysine threonine and tryptophan were added to make this diet equal to the control corn soybean meal diet on the basis of swine ileal digestibility added. Same as diet 3 in Table 2.

[5] Standard error of the mean; nine replicates for PUN at the beginning, and ten to the others.

CONCLUSIONS

1. Digestible amino acid correction for diets formulated with complete substitution of soybean meal by cottonseed, poultry by-product meal or meat and bone meal, wheat bran, and crystalline amino acids is not enough to ensure the same performance in growing pigs fed *ad libitum*.

2. There is an improvement on response of diets formulated with low level of digestible amino acids when it is fortified with crystalline amino acids.

3. It seems that the lack of response on the concept of amino acid digestibility is due to the difference in consumption of the pigs as shown by similar performance when pair fed.

4. Palatability may be a factor to consider when using alternative feed ingredients to formulate swine diets based on amino acid digestible estimates.

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