Influence of feed grade amino acid inclusion level in late nursery and grower diets fed to pigs from 10 to 35kg[1]

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Abstract

A total of 912 pigs (PIC TR4 × (Fast LW × PIC L02)) were used in a 43-d trial to evaluate the influence of feed grade amino acid levels in late nursery and grower diets containing 30% dried distiller's grains with solubles (DDGS) on growth performance. Pigs were randomly assigned to pens containing 19 pigs per pen. Pens were then randomly allotted in weight blocks to 1 of 4 dietary treatments with 12 replicate pens per treatment. Treatment diets were fed in two phases from 10 to 19.5 kg and 19.5 to 35 kg with digestible (SID) lysine (Lys) at 1.31 and 1.15%, respectively. Predetermined orthogonal contrasts were used to evaluate linear or quadratic effects based on percentage of SID Lys from intact protein versus feed grade lysine. Dietary treatments contained either a low, medium, high, or very high level of feed grade amino acids with L-lysine added at 0.25, 0.40, 0.55, and 0.70% of the diet, respectively, with all other amino acids added as needed to meet or exceed minimum ratios relative to Lys ,which were 60% Isoleucine (Ile); 58% Methionine and Cysteine (Met + Cys); 65% Threonine (Thr); 19% Tryptophan (Trp); 72% Valine (Val). Overall, from d 0 to 43, there was an increase (quadratic, $P < 0.020$) in average daily gain (ADG) and average daily feed intake (ADFI) with pigs fed increasing levels of feed grade amino acids having the greatest gain and feed intake at the medium and high inclusion of feed grade amino acids, respectively. For overall feed:gain (F:G), pigs fed the medium level of feed grade amino acids had improved F:G ($P = 0.002$) compared to pigs fed the high and very high feed grade amino acids with the pigs fed the low feed grade amino acids intermediate. In summary, feeding pigs medium levels of feed grade amino acids resulted in increased ADG and F:G during the late nursery and grower period.

Background

The advancements in amino acid (AA) fermentation technology now provide nutritionist with eight of the 10 essential amino acids (EAA) to use in formulating feeds. These advancements offer the nutritionist several options to meet differing global demands from reduced nitrogen (N) excretion, fortifying diets using unique feedstuffs while providing the desired ideal amino acid pattern. While many opportunities are opened with the introduction of a new synthetic AA, it also brings new challenges. It is generally accepted among swine nutritionist that dietary protein levels can be reduced by 3 to 4% units using the four crystalline AA sources (Lys, Thr, Met and Trp) without sacrificing growth, Feed conversion ratio (FCR) or carcass merit (Kerr et. al., 2003). However, when dietary protein levels are reduced beyond 4% units, the literature suggest a loss in both ADG and FCR. The objective of this experiment was to evaluate the addition increasing dietary levels of synthetic AA to the sixth limiting AA on the performance of late nursery and early grower pigs (10.0 kg to 35 kg).

Experimental Procedure

A total of 912 pigs (PIC TR4 × (Fast LW × PIC L02)) were used in a 43-d trial conducted in a commercial wean-to-finish research barn (New Fashion Pork, Jackson, Minnesota). The objective was to evaluate the impact of increasing feed grade amino acid supplementation in late nursery and grower pig diets containing 30% dried distiller's grains with solubles (DDGS) on growth performance. Pigs were randomly assigned to pens (19 pigs per pen). Then pens were randomly allotted by weight blocks to one of four dietary treatments with 12 replicate pens per dietary treatment.

Diets were corn – soybean meal base and contained 30% DDGS (Table 1). The trial consisted of a two-phase dietary program. Phase 1 diets were fed from 10.0 to 19.5 kg containing 1.31% of SID Lys and the Phase 2 diet fed from 19.5 kg to 35 kg contained 1.15% SID Lys. EAA to Lys ratios and other nutrients met or exceed NRC (2012) recommendations.

Table 1. Diet composition, as-fed basis

Ingredient, %	Feed grade amino acids							
	Phase 1[1]				Phase 2[2]			
	Low	Medium	High	Very High	Low	Medium	High	Very High
Corn	1.00	40.15	44.35	48.60	42.05	46.20	50.15	54.20
Soybean meal, 47%	30.80	26.25	21.75	17.20	24.90	20.55	16.30	11.95
Corn DDGS, 7.5% oil	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Choice white grease	1.05	0.90	0.70	0.50	1.00	0.90	0.70	0.50
Limestone	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Mono-calcium Phosphate	0.20	0.28	0.33	0.39	0.07	0.16	0.22	0.29
Sodium chloride	0.60	0.60	0.60	0.60	0.50	0.50	0.50	0.50
L-Lysine-HCl	0.25	0.40	0.55	0.70	0.24	0.39	0.53	0.67
DL-Methionine	0.11	0.15	0.20	0.24	0.08	0.11	0.15	0.19
L-Threonine	0.07	0.13	0.20	0.26	0.05	0.11	0.17	0.23
L-Tryptophan	-	0.03	0.05	0.08	-	0.03	0.05	0.08
L-Valine	-	0.03	0.10	0.18	-	-	0.08	0.15
L-Isoleucine	-	-	0.09	0.18	-	-	0.08	0.16
Phytase3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
GF VTM 5000	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrient analysis								
L-lysine as a proportion of total SID lysine, %	15	24	33	42	16	26	36	46
Standardized ileal digestible (SID) amino acid, %								
Lysine	1.31	1.31	1.31	1.31	1.15	1.15	1.15	1.15
Isoleucine:lysine	66	60	60	60	67	60	60	60
Leucine:lysine	151	142	133	124	159	149	140	130
Methionine:lysine	34	36	38	39	34	35	36	38
Methionine & cysteine:lysine	58	58	58	58	58	58	58	58
Threonine:lysine	65	65	65	65	65	65	65	65
Tryptophan:lysine	19.1	19.1	19.1	19.1	19	19.1	19.2	19.2
Valine:lysine	76	72	72	72	78	72	72	72
Histidine:lysine	43	40	37	34	45	41	38	34
Total lysine, %	1.56	1.55	1.54	1.53	1.39	1.38	1.36	1.35
Net energy, kcal/lb	1154	1154	1154	1154	1159	1159	1159	1159
SID lysine:NE, g/mcal	5.15	5.15	5.15	5.15	4.5	4.5	4.5	4.5
Crude protein, %	26.4	24.9	23.4	22	24.1	22.6	21.2	19.8
Calcium, %	0.57	0.57	0.56	0.56	0.52	0.53	0.52	0.52
STTD P with phytase, %	0.43	0.43	0.43	0.43	0.39	0.39	0.39	0.39
Analyzed Ca:STTD P	1.33	1.33	1.3	1.3	1.33	1.33	1.33	1.33

[1] Phase 1 was fed from d 0 to 21.
[2] Phase 2 was fed from d 21 to 43.
[3] Quantum Blue 10G (ABVista, Marlborough, Wiltshire) provided an estimated release of 0.13% Available P.

Dietary treatments were LOW level of AA supplementation containing only four added synthetic AA's (Lys, Thr, Met and Trp) similar to US industry standards. The MEDIUM diet had higher level of four supplemented AA plus L-Valine (Val). The HIGH diet had incremental higher levels of synthetic AA and included both Val and L-Isoleucine (Ile). The VERY HIGH diet was balanced to provide a minimum Histidine to Lysine ratio of 34% (NRC. 2012) by increasing supplementation levels of the six synthetic AAs (Lys, Thr, Met, Trp, Val and Ile). A composite feed samples of 500 g for each diet treatment and phase were stored at -20°C until analyzed.

Pens of pigs were weighed, and feed disappearance calculated on d 10, 21, 31 and 42 to determine ADG, ADFI, and F:G. Blood was collected from four pigs per pen, 2 barrows and 2 gilts of medium size, on d 21 and 42 to measure blood urea nitrogen. Pigs that are bled on d 21 were identified by unique ear tag were bled again on d 42 to determine blood urea nitrogen (BUN).

Data were analyzed as a RCB design with pen serving as the experimental unit. Weight block was included in the statistical model as a random effect and treatments compared based on mean separation. Results were considered significant $P \leq 0.05$, and marginally significant at $P \leq 0.10$. Additionally, orthogonal contrasts were conducted to determine the presence of a linear and/or quadratic effect of increasing AA supplementation level.

Results

Increasing the level of synthetic AA decreased total dietary crude protein (CP) levels in the LOW to VERY HIGH diets from 26.4 to 22.0% in Phase 1 (Table 2). Dietary CP level in Phase 2 were decreased from 24.1 to 19.8%. While these CP levels appear high relative to other global regions, all diets contained 30% DDGS which greatly increases total protein due to its high levels of non-essential AA's. Nevertheless, total dietary CP was reduced by 4.3 to 4.4% percentage units or by 20% of total dietary CP with increasing dietary EAA supplementation.

Table 2. Analyzed experimental diets, as fed basis[1]

Ingredient, %	Feed grade amino acids							
	Phase 1[1]				Phase 2[2]			
	Low	Medium	High	Very High	Low	Medium	High	Very High
Analyzed total lysine	1.44 (1.56)	1.53 (1.55)	1.51 (1.54)	1.48 (1.53)	1.38 (1.39)	1.43 (1.38)	1.35 (1.36)	1.41 (1.35)
Isoleucine:Lysine	77 (65)	70 (60)	65 (60)	67 (60)	74 (66)	66 (60)	62 (60)	66 (60)
Leucine:Lysine	153 (146)	142 (139)	132 (132)	128 (124)	156 (153)	143 (145)	130 (137)	129 (129)
Methionine:Lysine	37 (32)	38 (33)	38 (35)	37 (37)	35 (32)	33 (33)	31 (34)	36 (36)
Methionine & Cysteine:Lysine	65 (57)	65 (57)	62 (57)	61 (57)	64 (57)	59 (57)	56 (57)	60 (57)
Threonine:Lysine	69 (67)	65 (67)	64 (67)	66 (67)	67 (68)	66 (68)	63 (67)	64 (67)
Tryptophan:Lysine	18 (19)	16 (19)	20 (19)	19 (19)	17 (19)	17 (19)	19 (19)	16 (19)
Valine:Lysine	88 (77)	82 (74)	78 (73)	80 (74)	86 (79)	77 (73)	73 (74)	77 (73)
Histidine:Lysine	46 (43)	42 (40)	38 (37)	36 (35)	46 (44)	41 (41)	38 (38)	35 (35)
Crude protein	24.54	23.25	20.56	20.86	23.3	20.82	19.17	19.69
Moisture	11.63	11.84	11.77	11.71	11.69	11.78	12.40	11.80
Crude fat	4.62	4.40	4.41	4.10	4.38	4.39	4.37	4.21
Crude fiber	3.76	3.66	3.56	3.40	3.90	3.78	3.24	3.54
Ash	5.71	5.44	4.96	5.11	4.82	5.18	4.10	4.29

[1] All samples were sent to the Agricultural Experiment Station Chemical Laboratories (Columbus, MO) for complete amino acid profile and proximate analysis.
[2] Phase 1 was fed from d 0 to 21.
[3] Phase 2 was fed from d 21 to 43.
[4] Numbers in parenthesis are the formulated values.

Analyzed total Lys levels in Phase 1 diets were close to formulated. Total Lys in Phase 1 tended to be lower for the LOW and VERY HIGH diet than formulated. EAA ratios to Lys were at or over formulated ratios, except Trp to Lys in MEDIUM diet in Phase 1 and Met + Cys to Lys in HIGH diet fed in Phase 2. Histidine (His) to Lys ratios exceeded 35% and would not be considered limiting (NRC, 2012) Increasing the dietary levels of synthetic AA in Phase 1 resulted in a linear ($P < 0.001$) increase in ADFI and consequential linear ($P < 0.001$) decrease in F:G ratio (Table 3). Pigs fed HIGH AA diet had higher ($P < 0.05$) ADFI than pigs fed the LOW AA diet. However, there were no differences ($P < 0.10$) in ADG therefore resulting in significant ($P < 0.05$) decrease F:G ratio was noted between the LOW and HIGH synthetic diets.

Table 3. Effect of feed grade amino acid levels in late nursery and grower diets on growth performance[1]

Item	Low synthetic AA	Medium synthetic AA	High synthetic AA	Very high synthetic AA	SEM	P-value, linear	P-value, quadratic
BW, kg							
d 0	9.710	9.710	9.710	9.710	0.144	0.904	0.791
d 11	13.880	14.060	14.200	14.150	0.204	0.121	0.326
d 21	19.280	19.370	19.820	19.600	0.277	0.140	0.423
d 32	25.440	25.810	26.170	25.810	0.382	0.179	0.130
d 43	33.200	34.330	33.970	33.610	0.503	0.534	0.032
d 0 - 21							
ADG, kg	0.454	0.458	0.482	0.463	0.009	0.185	0.329
ADF, kg	0.644^{b}	0.667^{ab}	0.703^{a}	0.699^{a}	0.013	0.001	0.213
F:G	1.42^{b}	1.46^{ab}	1.47^{ab}	1.51^{a}	0.018	0.001	0.884
d 21 - 43							
ADG, kg	0.617^{b}	0.676^{a}	0.640^{ab}	0.644^{ab}	0.016	0.528	0.045
ADFI, kg	1.166^{b}	1.216^{ab}	1.234^{a}	1.207^{ab}	0.024	0.059	0.036
F/G	1.89^{ab}	1.80^{b}	1.94^{a}	1.88^{ab}	0.024	0.210	0.546
Overall							
ADG, kg	0.535^{b}	0.567^{a}	0.562^{ab}	0.553^{ab}	0.01	0.204	0.02
ADF, kg	0.903^{b}	0.943^{ab}	0.975^{a}	0.957^{a}	0.017	0.001	0.016
F:G	1.69^{ab}	1.66^{b}	1.74^{a}	1.73^{a}	0.014	0.005	0.752

a,b,c Means within a row with different superscripts differ ($P \leq 0.05$).

[1] A total of 912 pigs (initially 21.4 lb) were used in a 43-d trial at New Fashion Pork research facility, Jackson MN. There were 19 pigs per pen and 12 replications per treatment.

[2] Treatment diets were manufactured at New Fashion Pork feed mill, Estherville, IA.

[3] BW = body weight, ADG = average daily gain, ADF = average daily feed intake, F:G = feed gain ratio.

During Phase 2 (22 to 42-d), ADG was increased in quadratic ($P < 0.05$) manner was noted with increasing dietary synthetic AA inclusion. Daily gain was increased ($P < 0.05$) with increasing synthetic AA level from the LOW to the MEDIUM diet with ADG of the HIGH and VERY HIGH diet being intermediate ($P > 0.10$). Daily feed intake also followed a similar significant quadratic ($P < 0.05$) response, with ADFI increasing with the additional synthetic AA supplementation from the LOW significantly different ($P < 0.05$) to the HIGH diet with the MEDIUM and VERY HIGH diet being intermediate. Feed efficiency (F:G), was optimized on the MEDIUM diet and lower ($P < 0.05$) than the HIGH diet, with the LOW and VERY HIGH level of AA supplementation being intermediate.

Over the 42-d trial, increasing dietary level of supplemental AA resulted in an quadratic ($P < 0.05$) increase in both ADG and ADFI. Increasing supplemental AA from the LOW to MEDIUM diet increased ($P < 0.05$) ADG with the HIGH being intermediate by numerically similar to the MEDIUM diet (0.567 and 0.562 kg/f-day, respectively). Further increase of supplemental AA to VERY HIGH diet resulted in numerically lower but statistically similar ($P > 0.10$) ADG. The increase in ADG was result of quadratic ($P < 0.05$) increase in ADFI with increasing AA supplementation. Feed intake increased in a step-wise fashion with increasing AA supplementation from the LOW to MEDIUM up the HIGH diet and tended to decrease at the VERY HIGH level of supplementation. Feed conversion ratio was maximized on the MEDIUM diet and was significantly better ($P < 0.05$) than the HIGH or VERY HIGH diets with the LOW diet being intermediate.

BUN decreased in a linear ($P < 0.001$) manner with increasing AA supplementation at day 21 (Figure 1). Decreasing dietary CP with increasing levels of AA supplementation decreased BUN by 40% from the LOW (14.5 mg/dl) to the VERY HIGH diet (8.8 mg/dl) reflecting changes in total protein intake.

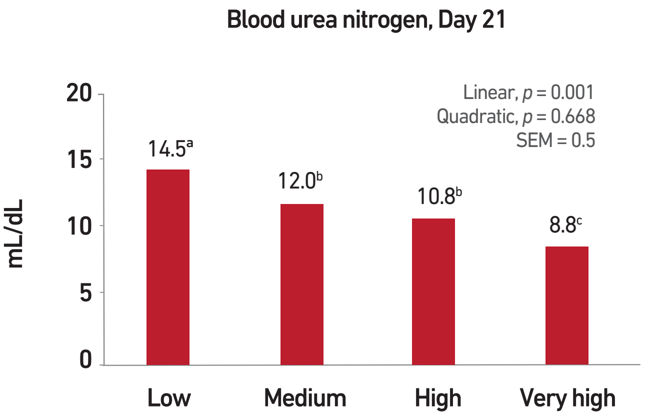

Figure 1. Blood Urea Nitrogen

Discussion

Performance in the present study was improved (P < 0.05) with the addition increased levels of supplemental AA and decreasing SBM up to the MEDIUM supplementation level. This diet contained approximately 0.40% added L-Lys-HCl and with Thr, Met, Trp and Val in Phase 1 and about 4.5% less SBM and 1.5 percentage units lower CP than the LOW diet. However, furthering increasing L-Lys-HCl to 0.55% and 0.70%, with further reduction in dietary CP of 1.5 and 1.4 percentage units of CP in the HIGH and VERY HIGH diets, respectively, resulted in lower numerical performance but statistically similar (P > 0.10) to the LOW Diet. Similarly, Kerr et, al. (2003) reported that performance in swine could be maintained up 4.0% reduction in dietary CP. In the current study statically similar (P > 0.10) performance was observed even with decreasing dietary CP level down 4.3 percentage units or by approximately 20%. Albeit, there was numerical trend for increased ADFI and loss of feed efficiency.

Powell et. al. (2011) in a series of experiments noted similar ADG, by increases in ADFI and deteriorating FCR when supplementing EAA growing pigs fed a 13% CP vs 18% CP corn-SBM based diets. With the addition of Glycine, authors were able to restore ADG to positive control, but not FCR due to increased ADFI. This result suggests non-limiting AA or nitrogen (N) is perhaps limiting for necessary body functions or protein synthetic. However, in the present study, dietary CP levels were higher (over 19%) during the same grower phase due to the inclusion of 30% DDGS used. These levels of CP should have provided sufficient level of non-essential amino acids (NEAA) to meet metabolic needs.

If NEAA and N are not limiting, then why was FCR comprised? In most studies examining increased supplemental EAA with corresponding lower dietary CP report increases in ADFI. Many experienced nutritionists would suggest this is the sign of a marginal deficiency in which the animal is attempting to meet a nutrient requirement by increasing ADFI. If this the case, what is limiting, NEAA, EAA? In the current trial, dietary CP levels should have been sufficient to meet NEAA needs as the CP levels exceeded those of positive control diet employed by Powell et. al. (2011). Does this perhaps suggest EAA to Lys ratios are incorrect? In the present trial, Thr, Met + Cys, Trp, Val and Ile to Lys ratios were at or above current NRC (2012) estimates. Additionally, the seventh limiting EAA, Histidine ratio to Lys were over 35% well above NRC (2012). While it is possible one or more of these EAA to Lys ratios could be limiting in the current diet due to ingredient profile.

There is a growing belief among nutritionist that there is maximum Lys to CP level to maintain performance. In the current study, the amount of L-Lys as a percentage of total dietary SID Lys ranged from 15% in the LOW diet to over 44% in the VERY HIGH diet.

As new feed grade EAA become economically feasible in commercial diets, we must under how to maintain current performance levels, especially FCR when using these new tools. As nutritionist, we need to look deeper into other potential nutrient interactions, synthetic AA antagonisms or other physiological functions to understand how we continue to lead and improve the sustainability of global pork production.

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