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Abstract

Forty-eight finishing gilts (initial weight = 155 Â± 2 lb) were randomly assigned to one of eight experimental treatments in a 2 x 2 x 2 factorial arrangement with main effects including dietary lysine (.60 vs 1.00%), source of amino acid fortification (intact protein vs synthetic amino acids formulated on an ideal protein basis) and environmental temperature (thermoneutral (TN): 68Â°F vs hot, diurnal (HS): 82 to 95 Â°F). The ideal protein diets were formulated by using corn and soybean meal to meet the 5th limiting amino acid with additions of synthetic lysine, threonine, tryptophan, methionine, or isoleucine to meet the pigs estimated requirement. The ratios of other total amino acids relative to lysine were: threonine 66%, tryptophan 17%, methionine and cystine 56%, and isoleucine 63%. Average daily gain (ADG), average daily feed intake (ADFn, and feed efficiency (FIG) were similar for gilts fed the intact and ideal proteins diets. Increasing dietary lysine improved d 0-14 ADG and resulted in a numerical improvement for the overall study. Gilts in the HS environment ate less feed and had lower ADG than gilts at TN. A temperature X lysine interaction was observed for FIG. Increasing dietary lysine had no effect on FIG of gilts in the TN environment, but improved FIG of gilts in the HS environment. Carcass protein and lipid contents were improved for gilts in the HS environment and by increased dietary lysine. Accretion rates for protein and lipid, backfat thickness, and longissimus muscle area were improved in gilts fed 1.00% lysine. The source of amino acid fortification did not influence carcass characteristics. In conclusion, increased dietary lysine improved FIG and carcass leanness in gilts to a greater extent in HS than TN environments. However, no improvements were observed in growth performance or carcass traits from feeding ideal protein diets.; Swine Day, Manhattan, KS, November 19, 1992

Keywords

Swine day, 1992; Kansas Agricultural Experiment Station contribution; no. 93-142-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 667; Swine; Pigs; Lysine; Growth; Heat stress

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THE EFFECTS OF DIETS FORMULATED ON AN IDEAL PROTEIN BASIS ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING GILTS HOUSED IN A HOT DIURNAL ENVIRONMENT[1]

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Summary

Forty-eight finishing gilts (initial weight = 155 ± 2 lb) were randomly assigned to one of eight experimental treatments in a 2 × 2 × 2 factorial arrangement with main effects including dietary lysine (.60 vs 1.00%), source of amino acid fortification (intact protein vs synthetic amino acids formulated on an ideal protein basis) and environmental temperature (thermoneutral (TN): 68°F vs hot, diurnal (HS): 82 to 95°F). The ideal protein diets were formulated by using corn and soybean meal to meet the 5th limiting amino acid with additions of synthetic lysine, threonine, tryptophan, methionine, or isoleucine to meet the pigs estimated requirement. The ratios of other total amino acids relative to lysine were: threonine 66%, tryptophan 17%, methionine and cystine 56%, and isoleucine 63%. Average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (F/G) were similar for gilts fed the intact and ideal proteins diets. Increasing dietary lysine improved d 0-14 ADG and resulted in a numerical improvement for the overall study. Gilts in the HS environment ate less feed and had lower ADG than gilts at TN. A temperature × lysine interaction was observed for F/G. Increasing dietary lysine had no effect on F/G of gilts in the TN environment, but improved F/G of gilts in the HS environment. Carcass protein and lipid contents were improved for gilts in the HS environment and by increased dietary lysine. Accretion rates for protein and lipid, backfat thickness, and longissimus muscle area were improved in gilts fed 1.00% lysine. The source of amino acid fortification did not influence carcass characteristics. In conclusion, increased dietary lysine improved F/G and carcass leanness in gilts to a greater extent in HS than TN environments. However, no improvements were observed in growth performance or carcass traits from feeding ideal protein diets.

(Key Words: Pigs, Lysine, Growth, Heat Stress.)

Introduction

When diets are formulated on an ideal protein basis, amino acids are provided in the exact proportions necessary for maintenance and protein accretion in a pattern in which every amino acid is equally limiting. Because all essential amino acids are equally limiting, this should reduce the amount of excess amino acids that must be metabolized. Theoretically, this would allow energy used in the breakdown and catabolism of excess amino acids to be used for growth, thus improving pig performance. Therefore, the objective of this experiment was to determine the effects of diets fortified with synthetic

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amino acids to produce an "ideal" amino acid pattern (NRC, 1988) in two types of environments (thermoneutral and heat stress) on performance of finishing gilts.

Experimental Procedure

A total of 56 crossbred gilts (Line 26, Pig Improvement Company, Franklin, KY) with initial BW of 155 ± 2 lb was used in the experiment. Eight gilts were slaughtered at the start of the study for determining initial carcass composition. Forty-eight gilts were blocked by weight and randomly assigned to one of eight experimental treatments in a 2 × 2 × 2 factorial arrangement with six replicate pens per treatment. The independent variables were temperature (thermonuetral: 68°F vs hot, diurnal: 82 to 95°F), dietary lysine (.60 vs 1.00%), and source of amino acid fortification (intact protein vs synthetic amino acids formulated on an ideal protein basis). The ideal protein diets (Table 1) were formulated by using corn and soybean meal to meet the 5th limiting amino acid. The synthetic amino acids added to achieve the desired dietary level were L-lysine•HCl, L-threonine, L-tryptophan, L-isoleucine, and D-L methionine. In the .60 and 1.00% lysine ideal protein diets, the order of limiting amino acids changed as the level of lysine increased; thus, the fifth limiting amino acids were calculated to be methionine and isoleucine, respectively. The ideal amino acid ratio used to formulate the diets was suggested for 110 to 240 lb pigs by NRC (1988) and used total amino acid values. The ratios of other amino acids relative to lysine were: threonine 66%, tryptophan 17%, methionine and cystine 56%, and isoleucine 63%. All diets were processed through a pellet mill equipped with a 4/16 in. die.

The facilities for this experiment consisted of four environmental chambers in the Samuel Brody Climatology Laboratory in the Animal Sciences Research Center at the University of Missouri. The two thermoneutral (TN) chambers were maintained at 68°F with an average relative humidity of 50%. The other two chambers used for the heat stress treatment (HS) cycled from a low of 82°F between 12:00 am to 10:00 am to a high of 95°F between 11:00 am to 7:00 pm (an increase of 2°F/h). The relative humidity in these chambers fluctuated between 50 and 75%, inversely related to temperature. Each environmental chamber contained 12, 4 ft × 4 ft pens in order to individually house pigs. Each chamber room contained three pens per dietary treatment.

Gilts were electrically stunned and exsanguinated when live weight reached approximately 225 lb. The carcass was weighed and standard carcass measurements were recorded. In addition, the longissimus muscle area was evaluated for color, firmness, and marbling. The left side of the carcass was passed twice through a grinder equipped with a 1/4 in. die, and samples were analyzed for DM, CP, lipid, and ash content. Protein, lipid, moisture, and ash accretion rates were determined by differences between the average of the initial eight gilts and final individual carcass composition.

Results and Discussion

Growth Performance. No temperature × lysine × amino acid source interactions were observed ($P > .05$) for average daily gains (ADG), average daily feed intake (ADFI), and feed efficiency (F/G). A temperature × amino acid source interaction ($P < .10$) was found for ADG during d 0-14. Gilts in the TN environment consuming the ideal and intact protein diets had ADGs of 2.25 and 2.03 lb; however, gilts in the HS environment had ADGs of 1.5 and 1.68 lb, respectively. Also, a tendency for a temperature × dietary lysine interaction was observed ($P = .07$) for ADG d 0-28 (Table 2). Average daily gain increased for gilts in the HS environment as dietary lysine increased from .60 to 1.00% (1.39 and 1.68 lb, respectively), whereas gilts at TN were not affected (2.09 and 2.05 lb, respectively). During d 0-14, ADG for gilts fed the 1.00% lysine diet was higher (P = .01) compared to gilts fed the .60% lysine diet (2.03 and 1.65 lb) regardless of environmental temperature. Average daily gain was similar for gilts fed either .60 or 1.00% lysine during d 0-28 and the overall test period, (P = .23 and .38, respectively). Gain for gilts consuming the intact and ideal protein diets were 1.76 and 1.83 lb, respectively (P = .68). Overall, gilts in the HS environment grew slower than gilts at TN (P = .01; 1.50 and 2.07 lb)

A temperature × amino acid source interaction (P = .01) was observed for ADFI d 0-14. Average daily feed intakes for gilts fed ideal protein in the HS environment were lower than those of gilts fed intact protein diets (5.66 and 4.67 lb), whereas at TN, the opposite occurred (6.17 and 7.19 lb). Overall, feed intakes for gilts fed the intact and ideal protein diets were 5.66 and 5.77 lb (P = .64). As expected, gilts in the HS environment consumed less feed than gilts at TN (P = .01; 4.96 and 6.48 lb).

Over the entire study, a temperature × dietary lysine interaction (P = .01) for feed efficiency was observed (Table 2). Feed efficiency was improved when dietary lysine increased from .6 to 1.00% in the HS environment; however, no differences were noted for gilts in the TN environment. Feed efficiencies for gilts fed the intact and ideal protein diets were 3.22 and 3.13, respectively. Gilts in the HS environment tended (P = .16) to have poorer feed efficacy than gilts at TN. Because pigs were removed at a constant final weight, the number of days on trial varied from 28 to 49. Pigs in the HS environment required 9.9 additional days (P = .01) to reach 225 lb (Table 2).

Carcass Composition and Tissue Accretion Rates. A tendency (P = .07) for a temperature × dietary lysine × amino acid source interaction was observed for carcass protein composition (Table 3). Carcasses from gilts in the HS environment consuming the 1.00% lysine protein diets had the highest percentage of carcass protein. A tendency (P = .07) for a lysine × amino acid source interaction also was observed for carcass protein composition. The amount of carcass protein with the .60% lysine ideal protein diets was reduced when compared to carcasses from gilts fed the .60% lysine intact protein diets (15.89 and 16.05%); however, carcass protein was found to higher in the gilts fed the 1.00% lysine ideal protein diets vs the 1.00% lysine intact protein diets (16.94 vs 16.50%). An inverse relationship for carcass fatness resulted in a dietary lysine × amino acid source interaction (P = .05). Percentages carcass lipid for the .60% lysine intact and ideal protein diets and the 1.00% lysine intact and ideal protein diets were 28.49, 29.83, 27.05, and 25.74, respectively.

Carcass of gilts fed 1.00 vs .60% dietary lysine contained (P = .01) higher amounts of moisture (54.13 and 51.89%), protein (16.72 and 15.97%) and less lipid (26.39 and 29.17%). Also, carcasses from gilts in the HS environment contained higher amounts of moisture (54.19 and 51.83%), protein (16.70 and 15.99%), and less lipid (26.29 and 29.27%). As a result of the reduced growth rate for the gilts raised in the HS environment, accretion rates for moisture (132.52 and 166.52 g/d), protein (45.24 and 57.50 g/d) and lipid (110.77 and 201.72 g/d) were reduced (Table 3). Gilts fed 1.00% lysine vs .60% dietary lysine also had increased protein accretion (P = .15; 54.97 vs 47.76 g/d) and decreased lipid accretion (P = .08; 139.30 vs 173.11 g/d).

Carcass Characteristics. An interaction for dietary lysine × amino acid source occurred for average backfat thickness (P = .07). Gilts fed the ideal and intact protein diets with .60% dietary lysine had average backfat thicknesses of 1.20 and 1.10 in., respectively (Table 4), whereas diets with 1.00% dietary lysine resulted in less average backfat for the ideal vs the intact protein diets (1.06 vs 1.10 in., respectively). Gilts fed 1.00% dietary lysine had less (P = .01) leaf fat, backfat thickness, and tenth rib fat thickness; larger longissimus muscle area;

and decreased dressing percentage (P = .05) than gilts fed .60% dietary lysine. Also, gilts in the HS environment had a higher (P = .01) dressing percentage than gilts at TN (73.59 and 71.64%, respectively). Marbling (P = .10) and firmness (P = .32) scores for gilts fed .60 and 1.00% were 1.93 vs 1.65 and 2.54 vs 2.40, respectively. Gilts fed the intact compared with the ideal protein diets had marbling scores of 1.85 and 1.71, respectively (P = .33).

Our data indicate that HS was primarily responsible for altering ADG and ADFI with little influence from lysine level and source of amino acids. The depressed ADG observed in the HS gilts can be largely attributed to the 23.7% decrease in ADFI and resulting in lower lysine intakes. Feeding the ideal compared to the intact protein diets at TN numerically increased ADG and ADFI, but not at HS (P > .05). Increasing dietary lysine had no effect on feed efficiency in gilts housed in a TN environment, but improved feed efficiency in gilts in a HS environment. Source of amino acid fortification did not influence feed efficiency. Dietary lysine influenced carcass composition and characteristics to a greater degree than did source of amino acid fortification. Carcasses from gilts fed .60% dietary lysine contained more lipid and less protein than carcasses from gilts consuming the 1.00% dietary lysine. Consequently, carcass characteristics for lipid (i.e., average backfat, leaf fat, tenth rib fat, and marbling) and protein (longissimus muscle area) were affected accordingly (P < .10).

In conclusion, results of this experiment indicate that gilts (150 lb) respond to increased dietary lysine with improved feed conversion and carcass leanness under heat stress; however, source of amino acid fortification did not influence growth performance, carcass characteristics, or quality. Thus, low-protein amino acid-fortified diets may be efficiently utilized by the ad libitum fed finishing pig. The future application of such diets will be evaluated on an economic basis. It would appear that the potential energy conservation from minimizing excess amino acids may not be great enough to influence pig performance or that minor excesses or deficiencies possible by formulating on a total amino acid basis in this study prevented expression of superior performance. However, factors such as growth rate and lean accretion, feed intake, environmental temperature, and gender may influence requirements to such an extent that one definitive ideal protein is impractical.

Table 1. Diet Composition[a]

	Percentage			
	.60% lysine		1.00% lysine	
Item	Intact	Ideal[b]	Intact	Ideal
Corn	84.48	93.85	70.53	79.58
Soybean meal, 48% CP	11.80	1.52	26.05	16.24
Monocalcium phosphate	1.12	1.31	.87	1.05
Soybean oil	1.00	1.00	1.00	1.00
Limestone	.94	.97	.88	.92
Vitamin premix	.25	.25	.25	.25
Salt	.25	.25	.25	.25
Trace mineral premix	.10	.10	.10	.10
Selenium premix	.05	.05	.05	.05
L-Lysine•HCl	-	.36	-	.35
L-Threonine	-	.10	-	.14
L-Isoleucine	-	.04	-	-
L-Tryptophan	-	.03	-	.01
DL-Methionine	-	-	-	.03
Calculated analysis				
ME, Mcal/lb	1.52	1.51	1.52	1.51
CP, %	12.74	8.69	18.29	14.46
Crude fat, %	4.40	4.68	3.99	4.25
Ca, %	.65	.65	.65	.65
P, %	.55	.55	.55	.55
Chemical analysis, %				
Lysine	.60	.60	1.00	1.00
Arginine	.75	.44	1.18	.88
Histidine	.36	.25	.52	.41
Isoleucine	.54	.38	.83	.63
Leucine	1.33	1.04	1.71	1.44
Methionine	.22	.17	.29	.28
Phenylalanine	.65	.44	.94	.74
Threonine	.45	.40	.67	.66
Tryptophan	.13	.10	.22	.17
Valine	.66	.44	.95	.75

[a] As fed basis.

[b] According to NRC (1988) suggested estimates, a .60 and a 1.00% lysine ideal protein diet would contain the following amino acid levels, Arg:.10, .17; His: .18, .30; Iso: .38, .63; Leu: .50, .83; Meth & Cys: .34, .56; Phe & Tyr: .55, .91; Thr: .40, .66; Try: .10, .17; Val: .40, .66%, respectively.

Table 2. Effects of Environmental Temperature, Dietary Lysine, and Amino Acid Source on Performance of Finishing Gilts[a]

	Thermoneutral[b]				Heat Stress										
	.60% Lysine		1.00% Lysine		.60% Lysine		1.00% Lysine			Contrasts					
Item	Intact[c]	Ideal[d]	Intact	Ideal	Intact	Ideal	Intact	Ideal	SE	Temp (T)	Lysine (L)	Source (S)	T×L	T×S	L×S
ADG, lb															
0-14 d	1.87	2.05	2.16	2.40	1.54	1.17	1.78	1.82	.15	.01	.01	.88	.56	.10	.29
0-28 d	2.03	2.18	1.98	2.12	1.43	1.32	1.61	1.74	.13	.01	.23	.44	.07	.57	.54
Overall	2.03	2.16	2.03	2.12	1.41	1.39	1.61	1.61	.13	.01	.38	.63	.22	.58	.88
ADFI, lb															
0-14 d	5.91	7.01	6.43	7.38	5.58	4.80	5.75	4.56	.57	.01	.60	.95	.55	.01	.71
0-28 d	6.19	6.76	6.26	6.67	5.11	4.87	5.22	4.78	.37	.01	.99	.77	.97	.12	.72
Overall	6.22	6.74	6.33	6.64	4.91	5.03	5.18	4.70	.33	.01	.93	.64	.93	.22	.39
Feed/gain															
0-14 d	3.13	3.33	2.94	2.85	3.57	4.00	3.13	2.50	.33	.46	.01	.67	.19	.49	.12
0-28 d	3.03	3.13	3.13	3.13	3.57	3.70	3.23	2.78	.25	.25	.07	.36	.02	.34	.22
Overall	3.13	3.13	3.13	3.13	3.57	3.57	3.23	2.85	.15	.16	.06	.49	.02	.38	.27
Avg days on trial	36.16	35.00	33.83	35.00	49.00	45.50	42.00	43.16	3.00	.01	.18	.78	.41	.78	.41

[a] A total of 48 gilts with an average initial weight of 156 lb. Pigs were removed from the experiment when weight reached 225 lb.

[b] Thermoneutral: 68°F, relative humidity 50%. Heat stress: 82° to 95°F.

[c] Soybean meal was the primary source of amino acid fortification to the diet.

[d] Synthetic amino acids were the primary sources of amino acid fortification to the diet.

Table 3. Effects of Environmental Temperature, Dietary Lysine, and Amino Acid Source on Carcass Chemical Composition and Tissue Accretion Rates of Finishing Gilts[a]

	Thermoneutral[b]				Heat Stress										
	.60% Lysine		1.00% Lysine		.60% Lysine		1.00% Lysine			Contrasts					
Item	Intact[c]	Ideal[d]	Intact	Ideal	Intact	Ideal	Intact	Ideal	SE	Temp (T)	Lysine (L)	Source (S)	T×L	T×S	L×S
Carcass Composition, %															
Moisture	51.76	50.51	51.76	53.28	53.51	51.78	55.55	55.94	.77	.01	.01	.63	.13	.47	.03
Protein[d]	16.01	15.50	15.88	16.58	16.10	16.28	17.13	17.31	.22	.01	.01	.40	.09	.78	.07
Lipid	29.33	30.81	29.51	27.41	27.70	28.85	24.56	24.06	.93	.01	.01	.98	.08	.63	.05
Ash	2.60	2.96	2.81	3.03	2.85	2.85	2.83	2.88	.12	.98	.42	.09	.47	.16	.78
Tissue accretion, g/d															
Moisture	167.41	156.53	172.99	169.17	113.63	118.06	144.20	154.20	24.11	.05	.23	.99	.49	.68	.85
Protein	58.28	53.48	57.66	60.56	36.27	43.02	48.22	53.45	7.13	.01	.15	.61	.44	.50	.75
Lipid	207.87	225.56	205.61	167.83	110.60	148.39	88.58	95.51	26.30	.01	.08	.74	.84	.40	.25
Ash	7.50	12.31	10.50	12.36	6.83	7.47	9.06	6.63	2.37	.06	.51	.47	.80	.22	.37

[a] Data collected from 48 gilts with a final weight of 102.7 kg.

[b] Thermoneutral: 68°F, relative humidity 50%. Heat stress: 82 to 95°F.

[c] Soybean meal was the primary source of amino acid fortification to the diet.

[d] Synthetic amino acids were the primary sources of amino acid fortification to the diet.

[e] Temperature × lysine level × source interaction (P=.07).

Table 4. Effects of Environmental Temperature, Dietary Lysine, and Amino Acid Source on Carcass Characteristics and Organ Weights of Finishing Gilts[a]

	Thermoneutral[b]				Heat Stress										
	.60% Lysine		1.00% Lysine		.60% Lysine		1.00% Lysine			Contrasts					
Item	Intact[c]	Ideal[d]	Intact	Ideal	Intact	Ideal	Intact	Ideal	SE	Temp (T)	Lysine (L)	Source (S)	T×L	T×S	L×S
Carcass characteristics															
Avg backfat, in.	1.12	1.17	1.09	.98	1.10	1.24	1.09	1.44	.06	.17	.01	.33	.36	.06	.07
Tenth rib fat, in.	.83	.99	.80	.46	.89	.89	.80	.77	.06	.92	.01	.68	.62	.55	.10
Leaf fat, lb	2.40	2.65	2.24	2.16	2.38	2.77	2.11	1.98	.26	.61	.01	.45	.51	.84	.17
Carcass length, in.	30.00	30.40	29.60	30.80	31.00	30.40	30.80	30.10	.40	.21	.92	.76	.67	.01	.83
Longissimus muscle area, in.^{2}	4.99	4.88	5.57	5.37	5.23	5.32	5.51	6.11	.28	.15	.01	.60	.97	.21	.58
Dressing percentage	71.88	72.23	70.99	71.47	73.84	74.06	73.04	73.41	.53	.01	.05	.36	.90	.87	.85
Color[d]	2.00	2.08	2.16	2.25	2.33	2.08	2.00	2.01	.20	.90	.90	.90	.22	.50	.66
Firmness[e]	2.25	2.41	2.50	2.33	2.75	2.75	2.25	2.53	.19	.16	.32	.61	.11	.61	.92
Marbling[f]	1.83	2.16	1.90	1.50	2.08	1.66	1.66	1.47	.24	.46	.10	.33	.97	.46	.46

[a] Data collected from 48 gilts with a final weight of 102.7 kg. Final weight was used as a covariate for leaf fat, avg backfat, tenth rib fat, carcass length, longissimus muscle area and organ weights.

[b] Thermoneutral: 68°F, relative humidity 50%. Heat stress: 82 to 95°F.

[c] Soybean meal was the primary source of amino acid fortification to the diet.

[d] Synthetic amino acids were the primary sources of amino acid fortification to the diet.

[e] Based on a scale with 1 = extremely pale, 3 = normal, 5 = extremely dark.

[f] Based on a scale with 1 = extremely soft, 3 = normal, 5 = extremely firm.

[g] Based on a scale with 1 = trace, 3 = small, 5 = abundant.