THE INTERACTIVE EFFECTS OF pST AND SALBUTAMOL ON THE LYSINE REQUIREMENT OF FINISHING PIGS[1]

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Summary

A metabolism study was conducted to evaluate the interactive effects of daily pST injections and the β-agonist salbutamol on the lysine requirement of finishing pigs based on nitrogen retention. Sixteen finishing pigs (137 lbs initially) were exposed to one of four biological treatments for 32 d. These treatments were: 1) non-treated control; 2) 4 mg/d pST; 3) 2.75 ppm of dietary salbutamol; 4) both salbutamol and pST. Pigs were kept on the same biological treatment and offered one of four diets for an 8 d period in a Latin square arrangement. Diets were formulated to contain .8, 1.2, 1.6, and 2.0% dietary lysine, the assumed first-limiting amino acid. Pigs were acclimated to each diet for a 4 d period, after which feces and urine were collected for 4 d to evaluate nitrogen retention. Results indicate that the β-agonist salbutamol increased the daily feed consumption, daily gain, and the efficiency of gain; whereas pST injection reduced feed consumption and increased efficiency of gain. No interaction occurred between pST and salbutamol for percent nitrogen retention; however, pigs injected with pST and fed salbutamol had a higher daily nitrogen retention because of an increased nitrogen intake and improved nitrogen utilization. Pigs treated with pST had leaner carcasses with a higher percent muscle than non-treated controls or pigs fed salbutamol. These data suggest that pigs injected with pST have a dietary lysine requirement between 1.2 and 1.6%, whereas those fed salbutamol have a requirement similar to that of non-treated pigs, which may be confounded with increased daily feed intake. Pigs treated with both pST and salbutamol appear to have a lysine requirement slightly lower than that of pigs injected with pST alone, which appears to be due to increased feed intake.

(Key Words: G-F, Lysine, Repartitioning, Hormone.)

Introduction

Recombinant porcine somatotropin (pST) has been shown to increase the dietary lysine requirement of finishing pigs. This is primarily a consequence of two phenomena. First, pigs injected daily with pST have significantly lower feed intakes than non-treated pigs; secondly, pST-treated pigs have faster rates of protein deposition. The combination of reduced feed consumption and increased net protein deposition leads to much higher requirement for lysine when expressed on a daily basis and when represented as a percent of the diet. The β-agonist salbutamol has been shown to improve longissimus muscle area and daily gains when included at 2.75 ppm of the diet. No data have been reported on the lysine requirement of pigs fed diets containing salbutamol; thus, establishing such a requirement serves to enhance our understanding of the growth-promoting effects of the β-agonist. Therefore, it was the objective of this study to evaluate the interactive effects of pST and

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salbutamol on the lysine requirement of finishing pigs.

Procedures

Sixteen pigs were randomly assigned to one of the four biological treatments imposed during the 32 d study. These treatments were: 1) non-treated control; 2) 4 mg/d pST; 3) 2.75 ppm of dietary salbutamol; 4) both 2.75 ppm salbutamol and 4 mg/d pST. Pigs received the same biological treatment throughout the study to avoid potential residual effects. The trial was further subdivided into four periods, each lasting 8 days. In the 8 d periods, pigs were fed each of four diets (Table 1) formulated to contain .8, 1.2, 1.6, and 2.0% lysine, the assumed first-limiting amino acid. During the first 4 days of each period, pigs were acclimated to the assigned diet, and during the subsequent 4-day period, both feces and urine were collected for calculation of daily nitrogen retention, percent nitrogen retention, apparent biological value of nitrogen, apparent nitrogen digestibility, and apparent dry matter digestibility. Percent nitrogen in the samples was determined using the Kjeldahl procedure for nitrogen determination. Ferric oxide (.1%) was included to mark the start and stopping points for feces collection. Data were analyzed as a split-plot design with biological treatments as whole plots and lysine levels as subplots. Pigs were assigned to diets by period according to a 4 × 4 Latin square design. Pigs were fed twice daily at a level equal to or exceeding their maximal intake during the previous 12 hour period, to allow ad libitum access to feed and water. After the last pig passed red marker, all pigs were slaughtered and carcass criteria measured. Measured performance criteria included: average daily gain (ADG), average daily feed intake (ADFI), and feed/gain (F/G).

Results and Discussion

Interaction means for the performance data are presented in Table 2, though no interactions between treatments for performance criteria were detected. Main effect means demonstrate that salbutamol (treatments 2 and 4 vs treatments 1 and 3) increases ADG (2.51 vs 2.02 lb, respectively; $P<.01$) and ADFI (6.76 vs 6.23 lb, respectively; $P<.04$) and improves F/G (2.79 vs 3.68, respectively; $P<.01$). Main effects of pST injection (treatments 3 and 4 vs treatments 1 and 2) were observed for reduced ADFI (5.46 vs 7.53 lb, respectively; $P<.001$) and F/G (2.55 vs 3.91, respectively; $P<.001$); however, because of the reduced intake, no differences were observed in ADG (2.29 vs 2.23 lb, respectively). No interactive effects occurred between pST, salbutamol, and lysine for growth parameters. However, an interaction was seen between pST × lysine ($P<.01$) for plasma urea nitrogen, indicating that pST-treated pigs did not break down absorbed amino acids to urea at rates similar to pigs not injected with pST. Dietary lysine level caused linear ($P<.04$) and quadratic ($P<.001$) reductions in ADFI, translating into a quadratic ($P<.04$) reduction in ADG. Performance data indicated that pigs treated with pST have a lysine requirement between 1.2 and 1.6%. This was supported by plasma urea nitrogen, which demonstrated linear, quadratic, and cubic ($P<.001$) increases with increasing lysine level. Pigs treated with salbutamol appeared to have no higher requirement for dietary lysine on a percentage basis than pigs not treated, which may be confounded because salbutamol increased ADFI.

Digestibility of dry matter and nitrogen (Table 3) were higher for pST-treated pigs (89.88 vs 88.34 for dry matter; 90.80 vs 88.53 for nitrogen; main effect, $P<.01$), whereas pigs treated with salbutamol did not alter the digestibility of dry matter or nitrogen. There were no interactive effects of pST and salbutamol for digestibility data, indicating different modes of action for the two compounds. Lysine level tended ($P<.15$) to cause quadratic improvements in dry matter digestibility and quadratic ($P<.02$) and cubic ($P<.05$) improvements in dietary nitrogen digestibility, demonstrating that dietary amino acid excesses are digested and utilized less

efficiently. This becomes clearer when using apparent biological value of dietary nitrogen (amino acids) as a measure of efficiency, where an interaction between pST and lysine ($P < .05$) is observed, indicating that pST-treated pigs benefit from increased lysine levels, resulting in improved biological value of nitrogen.

Retained nitrogen was interactively affected by pST and salbutamol when measured daily ($P < .14$) or as a percent of intake ($P < .10$), suggesting that salbutamol increases the efficiency of nitrogen utilization of pST-treated pigs. Significant interactions occurred between pST and lysine for daily nitrogen retention ($P < .07$) and percent nitrogen retention ($P < .05$), demonstrating that pigs injected with pST had improved nitrogen retention at higher lysine levels than non-injected pigs, with a maximum occurring between 1.2 and 1.6% lysine for daily nitrogen retention and between .8 and 1.2% lysine for percent nitrogen retention. Although no interaction was observed between pST, salbutamol, and lysine level, these data suggest that pigs treated with pST and salbutamol had a slightly lower lysine requirement than pigs treated with pST alone. This again may be interrelated to increased daily lysine intake with salbutamol.

Carcass data (Table 4) indicate that pST increased ($P < .01$) percent muscle, longissimus muscle area, and kidney and liver weight. Similarly, average backfat and tenth rib fat were decreased ($P < .001$) with pST administration, as well as kidney fat and dressing percent ($P < .01$). Salbutamol tended to reduce kidney and liver weight as a percent of live weight ($P < .09$ and $P < .02$, respectively), increase length ($P < .05$), and decrease carcass shrink ($P < .001$). Salbutamol and pST interactively ($P < .01$) influenced dressing percent, which was attributable to possible reductions in organ weights of salbutamol-treated pigs.

Conclusions

These data indicate that pigs injected daily with 4 mg pST have a lysine requirement between 1.2 and 1.6%. Furthermore, pigs fed salbutamol at 2.75 ppm of the diet do not appear to have a higher lysine requirement than non-treated pigs and appear to utilize an .8% level of lysine in the diet more efficiently. Subsequently, administration of pST and feeding salbutamol appear to be additive in terms of nitrogen retention and efficiency of utilization. Thus, pigs receiving both may respond adequately at a lower lysine level than pigs treated with pST alone, which may be related to increases in feed intake caused by salbutamol. These data are useful in determining the optimal range needed to observe maximal performance; however, they cannot recommend one value using such a wide range of lysine levels.

Table 1. Composition of Basal Diets (as fed)[a]

Ingredient, %	Lysine level, %[b]			
	.80	1.20	1.60	2.00
Corn	84.67	72.38	57.24	42.19
Soybean meal, 48%	-	12.50	28.00	43.35
Fish meal, select menhaden	5.00	5.00	5.00	5.00
Porcine plasma protein	5.00	5.00	5.00	5.00
Soybean oil	2.00	2.00	2.00	2.00
Monocalcium phosphate, 21% P, 18% Ca	1.96	1.75	1.48	1.21
Limestone	.66	.60	.54	.48
Salt	.25	.25	.25	.25
Vitamin premix	.25	.25	.25	.25
Trace mineral premix	.15	.15	.15	.15
L-lysine-HCl, 98%	.06	.11	.05	-
Dl-methionine, 99%	-	.01	.04	.10
L-threonine	-	-	-	.02
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Metabolizable energy , kcal/lb	1,507	1,508	1,511	1,514
Crude protein, %	13.71	18.66	24.70	30.69
Crude protein, %[b]	14.53	18.94	25.00	30.75
Tryptophan, %	.15	.23	.33	.42
Threonine, %	.64	.83	1.07	1.33
Methionine, %	.27	.34	.46	.59
Ca, %	.90	.90	.90	.90
P, %	.80	.80	.80	.80

[a]Salbutamol was included at 2.75 ppm to each diet.
[b]Analyzed content.

Table 2. Interactive Effects of pST, Salbutamol, and Lysine Level on Growth Performance and Plasma Urea Nitrogen of Finishing Pigs[a]

pST, mg/d	Salbutamol, ppm	Lysine, %	ADG, lb[b]	ADFI, lb[c]	Feed/gain, lb/lb[d]	PUN, mg/dl[ef]
0	0	.8	2.34	7.61	3.54	13.43
0	0	1.2	2.05	7.60	3.98	19.24
0	0	1.6	1.97	7.26	4.94	23.55
0	0	2	1.60	6.28	5.64	28.70
0	2.75	.8	2.89	8.76	3.07	17.93
0	2.75	1.2	2.49	8.11	3.29	23.37
0	2.75	1.6	2.30	7.57	3.62	27.87
0	2.75	2	2.20	7.07	3.22	36.30
4	0	.8	1.90	5.56	3.08	6.11
4	0	1.2	2.16	5.66	2.66	7.92
4	0	1.6	2.17	5.39	2.66	12.25
4	0	2	1.93	4.51	2.90	14.59
4	2.75	.8	2.50	6.05	2.45	5.85
4	2.75	1.2	2.88	6.10	2.15	8.07
4	2.75	1.6	2.71	5.18	1.94	12.13
4	2.75	2	2.10	5.23	2.58	14.95
		SE	.33	.32	.81	1.26

[a]Values are means of four pigs (137 lb average initial wt) fed each diet for 8 d periods.
[b]Main effect of salbutamol ($P < .01$); quadratic ($P < .11$) effect of lysine level.
[c]Main effects of pST ($P < .001$) and salbutamol ($P < .04$); linear ($P < .04$) and quadratic ($P < .001$) effects of lysine level.
[d]Main effects of pST ($P < .001$) and salbutamol ($P < .01$).
[e]Plasma urea nitrogen.
[f]Interactive effects of pST × salbutamol ($P < .14$) and pST × lysine ($P < .01$); main effects of pST ($P < .001$) and salbutamol ($P < .13$); linear, quadratic, and cubic effect of lysine level ($P < .001$).

Table 3. Interactive Effects of pST, Salbutamol, and Lysine Level on Finishing Pig Nitrogen Metabolism[a]

pST, mg/d	Salbutamol, ppm	Lysine, %	Digestibility, %		Nitrogen retained		Apparent BV, %[fg]
			Dry matter[b]	Nitrogen[c]	g/d[d]	%[e]	
0	0	.8	88.63	87.52	38.17	47.22	54.03
0	0	1.2	88.75	88.81	48.76	44.08	49.61
0	0	1.6	87.68	88.56	44.16	33.63	37.97
0	0	2	87.66	88.02	60.25	40.17	45.67
0	2.75	.8	89.14	88.55	53.92	52.33	59.10
0	2.75	1.2	88.47	88.10	50.95	46.17	52.31
0	2.75	1.6	88.31	88.62	64.35	45.75	51.93
0	2.75	2	88.09	90.08	85.26	51.61	57.27
4	0	.8	89.49	88.92	39.22	60.32	67.95
4	0	1.2	90.25	91.03	55.17	63.78	70.11
4	0	1.6	90.22	91.47	68.37	60.00	65.60
4	0	2	90.38	91.82	59.19	52.59	57.31
4	2.75	.8	89.81	89.65	45.53	64.24	71.66
4	2.75	1.2	90.09	90.70	58.04	64.69	71.47
4	2.75	1.6	89.49	90.95	66.11	60.14	66.24
4	2.75	2	89.35	91.87	69.58	55.95	60.82
		SE	.58	.77	5.95	3.24	3.55

[a]Values are means of four pigs (137 lb average initial wt) fed each diet for 8 d periods.
[b]Effect of pST ($P < .01$); quadratic effect of lysine level ($P < .15$).
[c]Main effect of pST ($P < .01$); quadratic ($P < .02$) and cubic ($P < .05$) effects of lysine level.
[d]Interactive effects of pST × salbutamol ($P < .14$) and pST × lysine ($P < .07$); main effect of salbutamol ($P < .02$); quadratic ($P < .001$) and cubic ($P < .02$) effects of lysine level.
[e]Interactive effects of pST × salbutamol ($P < .10$) and pST × lysine ($P < .05$); main effects of pST ($P < .001$) and salbutamol ($P < .01$); quadratic ($P < .01$) effect of lysine level.
[f]Apparent biological value of nitrogen.
[g]Interactive effects of pST × salbutamol ($P < .15$) and pST × lysine ($P < .05$); main effects of pST ($P < .001$) and salbutamol ($P < .02$); quadratic ($P < .001$) effect of lysine level.

Table 4. Interactive Effects of pST and Salbutamol on Carcass Characteristics of Finishing Pigs[a]

Item	pST, mg/d Salbutamol, ppm	0 0	0 2.75	4 0	4 2.75	SE
Muscle, %[b]		49.88	50.73	56.11	55.94	.97
Loin muscle area, in^2 [c]		5.03	5.22	5.71	6.11	.25
Average backfat, in[b]		1.47	1.50	1.21	1.23	.04
Tenth rib fat, in[b]		1.34	1.29	.84	.85	.09
Length, in[d]		29.30	29.68	28.26	29.78	.44
Kidney, g[b]		346.14	309.48	458.31	434.86	22.14
Kidney, %[be]		.37	.33	.49	.46	.02
Kidney fat, g[c]		1284.85	1289.31	932.20	727.31	141.01
Kidney fat, %[c]		1.36	1.38	.95	.80	.13
Liver, g[b]		1556.61	1488.93	1991.97	1779.40	77.89
Liver, %[bf]		1.68	1.57	2.17	1.86	.07
Dressing percent, %[bfg]		75.35	75.06	72.39	74.63	.36
Carcass shrink, %[h]		2.42	1.91	2.73	1.94	.11

[a]Values are means of four pigs per treatment, except for pigs receiving both pST and salbutamol, which is represented by five pigs. Average initial wt was 137 lb.
[b]Main effect of pST ($P < .001$).
[c]Main effect of pST ($P < .01$).
[d]Main effect of salbutamol ($P < .05$).
[e]Main effect of salbutamol ($P < .09$).
[f]Main effect of salbutamol ($P < .02$).
[g]Salbutamol × pST interaction ($P < .01$).
[h]Main effect of salbutamol ($P < .001$).