THE EFFECTS OF PORCINE SOMATOTROPIN (PST) DOSAGE AND DIETARY LYSINE LEVEL ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING SWINE[1]

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Summary

One hundred and forty-four finishing pigs (initial weight 126 lb) were utilized to determine the effects of PST dosage (4 or 8 mg PST·head^{-1}·day^{-1}) and dietary lysine level (.8, 1.0, 1.2, or 1.4%) on growth performance and carcass characteristics. Pigs were injected daily in the extensor muscle of the neck with either 4 or 8 mg PST and fed a pelleted corn-soybean meal-sesame meal diet containing .8% lysine. Additional lysine levels of 1.0, 1.2, and 1.4% were provided by L-lysine HCl. Control pigs (placebo injection) received the .8% lysine diet. All diets were formulated to contain at least 220% of NRC (1979) recommendations for other amino acids, vitamins and minerals. There were no PST x lysine interactions for any observed traits (P>.10), so only main effects are reported. Increasing level of dietary lysine resulted in linear improvements in average daily gain (ADG) and feed conversion (F/G) in PST-treated pigs. Adjusted backfat thickness (ABF) was lowered (linear P<.05), whereas longissimus muscle area (LMA) was increased (linear P<.05) with increasing lysine level. Pigs injected with 8 mg PST had similar ADG compared to 4 mg PST-treated pigs, and both were greater than controls (linear and quadratic P < .05%). Increasing PST dosage improved F/G (linear and quadratic P < .05), LMA and reduced ABF (linear P < .05). Urea concentrations determined in plasma on day 28 decreased (linear and quadratic P<.05) with increasing lysine level, whereas free fatty acids and insulin tended to increase (P<.10). Porcine somatotropin dosage decreased urea concentrations while glucose, insulin and free fatty acid concentrations increased (linear and quadratic P < .05) in plasma. Trimmed ham and loin weights were increased slightly (P >.10) by increasing dietary lysine level and were also increased (linear P < .10) by PST dosage.

Chemical composition of samples taken from the loin and belly revealed an increase in crude protein (linear and quadratic (P<.05) and a reduction in fat content (linear P<.05; quadratic P<.10) as lysine level increased. Increasing PST dosage also resulted in higher protein and less fat (linear and quadratic P <.05) in loin and belly samples.

These data confirm our previous results indicating that PST administration increases the dietary lysine requirement of finishing swine. Growth and carcass criteria were maximized by a dietary lysine level of 1.2 to 1.4%. Based on the expected feed intake of PST-treated pigs, this corresponds to a daily lysine intake of 30 to 36 g. However, this level of lysine appears adequate for both 8 and 4 mg PST-treated pigs. Average daily gain was optimized by the 4 mg PST dosage, and carcass traits were improved compared to control treated pigs. However, F/G and carcass traits were further improved by the 8 mg PST treatment. Therefore, results indicate that the percentage improvement in response (i.e., growth

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performance and/or carcass quality) expected from PST administration may be chosen by adjusting the dosage of PST administered to the pig.

(Key Words: Porcine Somatotropin, Dosage, Lysine Requirement, Growth Performance, Carcass Traits, Finishing Pigs.)

Introduction

Since 1985, several researchers have reported improvements in growth performance and carcass quality of swine from administration of exogenous PST. Daily injections of PST have increased protein and decreased fat deposition in finishing pigs and appear to delay the fattening phase of the pig's growth curve, resulting in a leaner carcass. However, these studies have only evaluated different dosages of PST and have not examined possible changes in the pig's nutritional requirements because of the accelerated growth rate. Since results of our initial study indicated a significant response in performance of PST-treated pigs to dietary lysine level, we felt that determination of an optimal PST dosage may also be influenced by the dietary lysine level. Therefore, we conducted the following experiment to evaluate two different dosages of PST in combination with increasing lysine level on finishing pig performance.

Procedures

The experiment was conducted in two separate trials, each including 72 barrows averaging 126 lb. Pigs were allotted on the basis of weight and ancestry to one of nine treatments arranged in a 2 x 4 factorial design with a control treatment. Main effects included PST dosage (4 or 8 mg $PST \cdot head^{-1} \cdot day^{-1}$) and dietary lysine level (.8, 1.0, 1.2, or 1.4%). Control pigs received a placebo injection and the .8% lysine diet (Table 1). Our initial experiment showed that .6% lysine was insufficient for PST-treated pigs and, therefore, the .8% lysine was chosen as the basal level. All diets were pelleted and calculated to contain at least 220% NRC (1979) recommendations for all other amino acids, vitamins, and minerals. This ensured that no nutrient other than lysine would limit performance. Feed and water were provided ad libitum, and pigs were housed with two pigs per pen and four treatment replications per trial. Pigs were weighe on day 14, 28, and again when the pen mean weight reached 230 lb. At this time, PST injections were terminated, and pigs were ultrasonically scanned for backfat thickness. Pigs were bled via vena cava puncture (4 hr postinjection and 3 hr postprandial) on day 14, 28, and again on the last day of PST injection. Following a 7-day withdrawal period, pigs were slaughtered, and carcass data were collected. All pigs from the first trial were slaughtered at a commercial processing plant where LMA and carcass length were measured. All pigs from the second trial were processed locally, and carcass measurements and organ weights were recorded. In addition, the entire right side of each animal was brought back to our laboratory for further analysis. The ham and loin were removed; evaluated for color, firmness, and marbling; then trimmed to 1/4 in fat thickness and weighed. The ham was then separated into its major individual muscles, and each one was weighed. A sample from the same anatomical region of the longissimus, ham (semimembranous), and the belly (below the last rib) was taken for determination of percentage moisture, crude protein, lipid, and ash.

Data were analyzed using a factorial design with a control treatment. Main effects included PST dosage and lysine level. Lysine main effects include linear, quadratic, and cubic comparisons, whereas control, 4 and 8 mg PST-treated pigs were compared using linear and quadratic comparisons. Since there were no trial x treatment or main effect interactions (P>.10), only main effects are reported.

Backfat, longissimus muscle area, and length were corrected to a constant weight (230 lb) using NPPC guidelines. Other carcass data were corrected using final weight as a covariate.

Results and Discussion

Increasing levels of dietary lysine resulted in up to a 24% increase (linear P<.05) in ADG for PST-treated pigs after 28 days or for the overall experiment (Table 2). At the same time, daily feed intake (FI) was reduced (linear P<.05), resulting in a 30% improvement in F/G (linear P<.05) compared to control pigs. Pigs injected with 4 or 8 mg PST were similar in ADG and both were 12% greater than control pigs (linear and quadratic P<.05). Increasing PST dosage lowered FI (linear P<.05) and, therefore, improved F/G (linear and quadratic P<.05) compared to control pigs. Both PST-treated groups gained faster and more efficiently than controls. These results are consistent with previous data, indicating that the magnitude of response to PST is dependent upon the dietary lysine level. Furthermore, ADG appeared to be optimized at the 4-mg dosage, yet because 8 mg PST dosage continued to further depress feed intake, a further improvement in efficiency was observed.

Concentrations of urea determined in plasma on day 28 decreased (linear and quadratic P<.05) with increasing lysine level, whereas PST dosage also lowered urea concentrations (linear and quadratic) compared to control pigs (Table 3). The changes in urea concentrations indicate that as dietary lysine level approached the pig's requirement, other amino acids were no longer catabolized but rather incorporated into proteins. Plasma glucose and creatinine concentrations were unaffected by lysine level. Plasma free fatty acids and insulin, on the other hand, tended to increase (P<.10) with increasing lysine level. Concentrations of glucose, insulin, and free fatty acids were higher (linear and quadratic P<.05) in PST-treated pigs than in control pigs, whereas creatinine levels decreased. These changes are a result of PST's effects on fat mobilization and carbohydrate metabolism.

Hot carcass weight and dressing percentage were unaffected by dietary lysine level (Table 4). However, unlike our previous study, control pigs had 4% heavier hot carcass weight and 3% higher dressing percentage (linear and quadratic P<.05) than PST-treated pigs. Adjusted backfat thickness decreased 20% and LMA increased 16% with increasing lysine level (linear P<.05) for PST-treated pigs compared to control pigs. Longissimus muscle area increased and ABF decreased with increasing PST level (linear P<.05). Carcass length was unaffected by experimental treatment; however, kidney fat (linear and quadratic P<.05) and loin and ham weight (linear P<.05) responded to PST treatment, because pigs injected with 8 mg PST had less kidney fat and heavier loins and hams than either control or 4 mg-treated pigs.

Individual ham muscle weights followed the same trend as trimmed ham weight, with most muscles showing an increase in weight with PST dosage, but only the biceps femoris, quadriceps femoris and amount of lean trim were increased with increasing lysine level (P<.05) (Table 5). Quality indicators such as color and firmness of the ham were improved with increasing PST dosage. Loin marbling was decreased as dietary lysine (linear and cubic P<.05) and PST dosage (linear P<.05 quadratic P<.10) increased, similar to the decreases observed in backfat thickness and kidney fat.

Longissimus samples had more protein and reduced fat content (up to 57%) as lysine level and PST dosage increased (linear and Quadratic P<.05; Table 6). This could be expected from the decrease in marbling scores, backfat, and kidney fat for PST-treated pigs. Semimembranous samples also decreased up to 25 and 34% in fat content by lysine level (linear P<.10) and PST dosage, respectively. Belly samples showed a 8% increase in protein content and a 23% decrease in lipid content with increasing lysine level (linear P<.05). Furthermore, pigs treated with 8 mg PST had 7 and 24% more protein than 4 mg PST-treated or control pigs, respectively (linear and quadratic P<.05). Pigs treated with either 4 or 8 mg PST had 35 and 51% less fat in belly samples compared to control pigs.

Weights of heart, liver, spleen, and lungs were unaffected by lysine treatment; however, kidney weight increased (linear P<.05) with increasing lysine level. Kidney and spleen weights were also increased (linear $P<.05$) as PST dosage increased. Pigs injected with 4 or 8 mg PST had numerically heavier organ weights than control pigs. The heavier organs would be responsible for the lighter carcass weight and lowered dressing percentage of PST-treated pigs compared to controls.

These data demonstrate that PST administration increases the lysine requirement of finishing swine. Growth performance and carcass characteristics were optimized for pigs fed 1.2 to 1.4% dietary lysine. In addition, increasing PST dosage did not increase the lysine level above that required by pigs injected with 4 mg PST. Average daily gain was maximized by the 4 mg PST dosage; however, F/G and carcass traits were improved with the higher dosage. Therefore, it would appear that the 4 mg dosage is suitable for optimizing ADG and improving carcass quality compared to control pigs. However, if further improvements in F/G and carcass quality are desired, a higher PST dosage (8 mg) would be required.

Table 1. Diet Composition[a]

Ingredient	Percentage
Corn	60.91
Sesame meal	10.00
Soybean meal	18.30
Soybean oil	5.00
Monocalcium phosphate	2.77
Limestone	.78
Salt	.50
Trace mineral premix[b]	.20
Vitamin premix[c]	.50
Selenium premix[d]	.05
Threonine	.17
Methionine	.05
Sucrose/L-lysine HCl[e]	.77
	100.00

[a]Calculated to contain: 17.6% crude protein, .8% lysine, .9% threonine, .23% tryptophan, 1.1% calcium, and 1% phosphorus.
[b]Contained 5.5% Mn, 10% Fe, 1.1% Cu, 20% Zn, 0.15% I, and 0.1% Co.
[c]Each lb of premix contained the following: vitamin A 800,000 IU, vitamin D 60,000 IU, vitamin E 4,000 IU, riboflavin 900 mg, d-pantothenic acid 2.4 g, choline chloride 92.2 g, niacin 5.0 g, B_{12} 4.4 mg, menadione dimethylpyrimidinol bisulfate 310 mg.
[d]Contained 90.0 mg Se/lb premix.
[e]Sucrose was replaced by L-lysine HCl to provide dietary lysine levels of 1.0, 1.2, and 1.4%.

Table 2. Main Effects of PST Dosage and Dietary Lysine on Growth Performance[a]

Item	PST, mg·day^{-1}			Lysine, %			
	0	4	8	.8	1.0	1.2	1.4
Daily gain, lb							
Day 28[bcd]	2.29	2.58	2.54	2.34	2.49	2.65	2.78
Overall[bcd]	2.27	2.62	2.64	2.50	2.55	2.66	2.82
Daily feed intake, lb							
Day 28[bef]	6.68	5.89	5.35	5.89	5.53	5.49	5.56
Overall[bdf]	6.70	6.13	5.62	6.26	5.79	5.66	5.78
Feed conversion, (F/G)							
Day 28[bcdg]	2.94	2.33	2.18	2.58	2.25	2.13	2.07
Overall[bcd]	3.02	2.39	2.23	2.54	2.30	2.25	2.14

[a]A total of 144 pigs, average initial weight 126 lb, average final weight 230 lb, trial duration 31 to 47 days. Observation per treatment: Control = 8; PST = 32; Lysine level = 16.
[b]Linear effect of PST ($P<.05$).
[c]Quadratic effect of PST ($P<.05$).
[d]Linear effect of lysine ($P<.05$).
[e]Linear effect of lysine ($P<.10$).
[f]Quadratic effect of lysine ($P<.10$).
[g]Quadratic effect of lysine ($P<.05$).

Table 3. Main Effects of PST Dosage and Dietary Lysine on Serum Criteria (day 28)[a]

Item	PST, mg·day^{-1}			Lysine, %			
	0	4	8	.8	1.0	1.2	1.4
Urea, mg/dl[bcef]	30.04	16.90	13.26	18.54	13.89	13.49	14.40
Glucose, mg/dl[b]	110.91	113.97	117.41	118.04	112.40	116.76	115.56
Creatinine, mg/dl[bc]	1.11	1.03	1.06	1.05	1.06	1.04	1.03
Free fatty acids, meq/L[bce]	208.75	353.19	341.34	321.04	344.31	328.31	394.50
Insulin, μU/ml[bce]	9.79	30.62	34.95	27.80	32.50	34.91	35.93

[a]A total of 144 pigs, average initial weight 126 lb, average final weight 230 lb, trial duration 31 to 47 days. Observation per treatment: Control = 8; PST = 32; Lysine level = 16.
[b]Linear effect of PST ($P<.05$).
[c]Quadratic effect of PST ($P<.05$).
[d]Linear effect of lysine ($P<.05$).
[e]Linear effect of lysine ($P<.10$).

Table 4. Main Effects of PST Dosage and Dietary Lysine on Carcass Characteristics[a]

Item	PST, mg·day⁻¹			Lysine, %			
	0	4	8	.8	1.0	1.2	1.4
Hot carcass weight, lb[bc]	155.91	149.11	148.52	149.18	149.13	148.44	148.50
Dressing percentage[be]	66.29	63.56	63.07	63.45	63.40	63.15	63.28
Adjusted backfat thickness, in[bf]	1.12	1.00	.91	1.01	.96	.93	.92
Longissimus muscle area, in^2 [bf]	5.29	5.82	6.27	5.86	5.98	6.07	6.26
Carcass length, in	31.04	30.98	31.16	31.20	30.94	31.05	31.08
Kidney fat, lb[bc]	2.30	1.61	1.40	1.63	1.42	1.59	1.39
Loin weight, lb[d]	14.29	14.75	15.20	14.91	14.93	15.00	15.05
Ham wt, lb[d]	16.79	17.39	18.09	17.45	17.81	17.75	17.95

[a]Data taken from 72 pigs. Observations per treatment: Control = 8; PST = 32; Lysine level = 16. Final weight used as a covariate.
[b]Linear effect of PST ($P<.05$).
[c]Quadratic effect of PST ($P<.05$).
[d]Linear effect of PST ($P<.10$).
[e]Quadratic effect of PST ($P<.10$).
[f]Linear effect of lysine ($P<.05$).

Jim Nelssen, swine extension specialist, discusses laboratory equipment in the new swine research lab.

Table 5. Main Effects of PST Dosage and Dietary Lysine on Muscle Weights, Color, Firmness, Marbling, and pH

Item	PST, mg·day^{-1}			Lysine, %			
	0	4	8	.8	1.0	1.2	1.4
Muscle, g							
Semimembranous	957.64	977.50	1041.79	993.07	1002.46	1012.14	1030.90
Semitendinosus[b]	353.37	387.26	400.73	389.38	387.92	393.45	405.22
Adductor[b]	277.37	309.89	329.57	305.11	327.01	323.15	323.67
Biceps femoris[c]	1323.07	1382.14	1462.87	1372.04	1431.71	1412.39	1473.88
Gastrocnemus[e]	525.74	541.70	561.33	539.91	563.63	541.84	560.69
Quadriceps femoris[bd]	974.41	1043.08	1090.34	1039.97	1066.89	1072.05	1087.93
Lean trim[bc]	1433.03	1555.41	1608.15	1511.52	1617.65	1566.33	1631.61
Femur, g[e]	351.18	366.12	377.44	369.26	375.03	365.50	377.31
Color							
Ham[e]	2.36	2.67	2.72	2.68	2.75	2.66	2.69
Loin[f]	2.87	3.05	2.96	2.90	3.14	3.19	2.78
Firmness							
Ham[de]	2.33	2.58	2.55	2.67	2.65	2.43	2.50
Loin[f]	2.68	2.73	2.80	2.75	2.84	2.91	2.56
Marbling							
Loin[bcgh]	1.58	1.07	1.02	1.32	.97	1.17	.72
pH, 24 hr							
Loin[f]	5.48	5.46	5.46	5.43	5.49	5.49	5.41

[a]Data taken from 72 pigs. Observations per treatment: Control = 8; PST = 32; Lysine level = 16. Final weight used as a covariate.
[b]Linear effect of PST ($P<.05$).
[c]Linear effect of lysine ($P<.05$).
[d]Linear effect of lysine ($P<.10$).
[e]Linear effect of PST ($P<.10$).
[f]Quadratic effect of lysine ($P<.05$).
[g]Cubic effect of lysine ($P<.05$).
[h]Quadratic effect of PST ($P<.10$).

Table 6. Main Effect of PST Dosage and Dietary Lysine on Muscle Composition

Muscle	PST, mg·day^{-1}			Lysine, %			
	0	4	8	.8	1.0	1.2	1.4
Longissimus							
Moisture, %[bcf]	73.53	74.63	74.80	74.44	74.71	74.75	74.96
Dry matter, %[bcf]	26.48	25.37	25.20	25.56	25.29	25.25	25.04
Crude protein, %[deg]	20.85	21.48	21.58	20.80	21.71	21.92	21.68
Lipid, %[bceg]	3.90	2.34	1.81	3.18	1.95	1.58	1.66
Ash, %	1.01	1.01	1.04	1.10	1.05	1.03	1.00
Semimembranous							
Moisture, %	74.07	74.45	74.83	74.54	74.65	74.62	74.75
Dry matter, %	25.93	25.54	25.17	25.46	25.35	25.38	25.25
Crude protein, %[h]	20.68	20.83	20.95	20,58	20.91	21.19	20.89
Lipid, %[e]	3.42	2.86	2.26	3.06	2.44	2.43	2.29
Ash, %	1.00	1.06	1.00	1.00	1.04	1.07	1.02
Belly							
Moisture, %[bce]	50.17	59.76	63.62	59.66	61.64	61.78	63.68
Dry matter, %[bce]	49.83	40.23	36.38	40.34	38.36	38.21	36.32
Crude protein, %[bceh]	13.61	16.71	17.88	16.40	17.50	17.57	17.72
Lipid, %[bce]	32.51	21.21	15.96	20.61	18.49	18.53	16.69
Ash, %[bcf]	.52	.75	.78	.73	.78	.76	.79

[a]Data taken from 72 pigs. Observations per treatment: Control = 8; PST = 32; Lysine level = 16.
[b]Linear effect of PST ($P<.05$).
[c]Quadratic effect of PST ($P<.05$).
[d]Linear effect of PST ($P<.10$).
[e]Linear effect of lysine ($P<.05$).
[f]Linear effect of lysine ($P<.10$).
[g]Quadratic effect of lysine ($P<.05$).
[h]Quadratic effect of lysine ($P<.10$).

Table 7. Main Effects of PST Dosage and Dietary Lysine on Organ Weights[a]

Organ weight, g	PST, mg·day^{-1}			Lysine, %			
	0	4	8	.8	1.0	1.2	1.4
Heart	329.59	350.24	363.36	366.32	353.05	349.30	358.51
Liver	1437.71	1687.30	1929.02	1622.68	1731.66	1751.97	2126.31
Kidney[bcd]	360.10	452.96	480.54	446.94	466.36	477.73	475.97
Spleen[b]	135.69	153.51	156.02	154.73	147.47	162.59	154.30
Lungs	656.50	687.67	683.80	687.23	711.21	670.14	674.36

[a]Data taken from 72 pigs. Observations per treatment: Control = 8; 4 and 8 mg PST = 32; Lysine level = 16. Final weight used as a covariate.
[b]Linear effect of PST ($P<.05$).
[c]Quadratic effect of PST ($P<.05$).