EFFECT OF PORCINE SOMATOTROPIN ON SLAUGHTER TRAITS, CARCASS CHARACTERISTICS AND CARCASS CHEMICAL COMPOSITION OF BARROWS AND GILTS

By

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TABLE OF CONTENTS

Chapter		Page
I.	INTRODUCTION	1
II.	REVIEW OF LITERATURE	3
	Aspects of Porcine Somatotropin and Swine Growth	3
	Relationship of Exogenous Somatotropin to Endogenous Growth Hormone	3
	Methods of Exogenous Somatotropin Administration	4
	Daily Injection	4
	Implants	5
	Optimum Dosage Level	5
	Mode of Action for Growth	6
	Hormones Involved in Growth	6
	Probable Mode of Action for Porcine Somatotropin	8
	Glucose Utilization	8
	Insulin Action	10
	Somatomedin Concentration	10
	Effect on Rate and Efficiency of Growth	11
	Effects of Administration During the Growing Phase	11
	Effects of Administration During the Finishing Phase	12
	Effects of Nutritional Level and Administration of Porcine Somatotropin	12
	Effect of Porcine Somatotropin on Carcass Traits	14
	Effects on Carcass Composition	14
	Fat Thickness	14
	Muscling	14
	Bone and Skin	16
	Effects on Meat Quality	16
	Effects on Carcass Chemical Composition	17
III.	EFFECTS OF RECOMBINANT PORCINE SOMATOTROPIN (rpST) AND SEX-CLASS ON SWINE SLAUGHTER TRAITS AND CARCASS QUALITY	19
	Abstract	19
	Introduction	20
	Materials and Methods	21
	Results	23
	Discussion	24
	Implications	26

Chapter Page

IV. EFFECTS OF RECOMBINANT PORCINE SOMATOTROPIN (rpST) AND SEX-CLASS ON PORK CARCASS CHEMICAL COMPOSITION 34

Abstract 34
Introduction 35
Materials and Methods 35
Results and Discussion 37
Implications 39

LITERATURE CITED 48

APPENDIX FAT FREE LEAN REGRESSION VALUES FOR BARROWS, GILTS, AND ALL SWINE 53

LIST OF TABLES

Table Page

Chapter II

1. Daily Gain and Feed Efficiency of Pigs in Response to Daily Somatotropin Treatment 13

2. Backfat Thickness and Loin Eye Area of Pigs in Response to Daily Somatotropin Treatment 15

3. Carcass Chemical Composition of Pigs in Response to Daily Somatotropin Treatment 18

Chapter III

1. Ration Composition 27

2. Slaughter Traits Stratified by Porcine Somatotropin Dosage 28

3. Slaughter Traits Stratified by Sex-class 29

4. Carcass Traits Stratified by Porcine Somatotropin Dosage 30

5. Carcass Traits Stratified by Sex-class 31

6. Cooking Properties and Shear Force Values for Loin Chops Stratified by Porcine Somatotropin Dosage 32

7. Cooking Properties and Shear Force Values for Loin Chops Stratified by Sex-class 33

Chapter IV

1. Carcass Components Stratified by Porcine Somatotropin Dosage 40

2. Carcass Components Stratified by Sex-class 41

3. Kilograms of Soft Tissue Protein, Lipid, Moisture and Ash Stratified by Porcine Somatotropin 42

Table Page

4. Kilograms of Soft Tissue Protein, Lipid, Moisture and Ash Stratified by Sex-class 43

5. Proximate Analyses of Soft Tissue Components Stratified by Porcine Somatotropin Dosage 44

6. Proximate Analyses of Soft Tissue Components Stratified by Sex-class . 45

7. Weight and Proximate Analyses of Femur and Rib Bones Stratified by Porcine Somatotropin Dosage 46

8. Weight and Proximate Analyses of Femur and Rib Bones Stratified by Sex-class 47

LIST OF FIGURES

Figure Page

Chapter II

1. Feedback System Regulating Growth Hormone Release 7

2. The Effects of Treating Pigs with Porcine Growth Hormone on Nutrient Partitioning 9

Appendix

1. Regression of Fat Free Lean (%) on Porcine Somatotropin (rpST) Dosage for Barrows 54

2. Regression of Fat Free Lean (%) on Porcine Somatotropin (rpST) Dosage for Gilts 55

3. Regression of Fat Free Lean (%) on Porcine Somatotropin (rpST) Dosage for All Swine 56

CHAPTER I

INTRODUCTION

Industry strives to produce a desirable product efficiently and at the lowest cost of production. In order for a business to remain competitive, the items produced by the company must change as the consumer's wants and needs change. Presently, consumers are concerned with nutrition and how they may improve their diets. Specifically, consumers want to reduce the amount of fat contained in their diets.

In the swine industry, rapid methods of improving performance and carcass traits are limited. However, porcine somatotropin (pST) has been shown to augment endogenous supplies of growth hormone thus achieving prolonged muscle growth and deterring the onset of rapid fattening. Machlin (1972) discovered that injection of porcine somatotropin (pST) improved swine growth performance as well as carcass characteristics. Early studies such as Machlin's used pituitary derived somatotropin (growth hormone) which was difficult to obtain in a consistent purity. Presently, recombinant porcine somatotropin (rpST) can be consistently produced providing an ample supply for research purposes. Evock et al. (1988), Kanis et al. (1990) and McNamara et al. (1990) reported that rpST is beneficial to hog growth and carcass characteristics.

Porcine somatotropin and recombinant porcine somatotropin, although not approved for commercial use, are primarily administered through daily injection. Frequent injections of pST and rpST would not be practical for the commercial swine producer. Subcutaneous implants such as those used in the

cattle industry have been suggested as a possible method of somatotropin administration.

The intent of this study was to examine the effects of rpST administration to barrows and gilts on the following characteristics: 1) slaughter traits 2) carcass composition and 3) chemical composition of carcass tissue.

CHAPTER II

REVIEW OF LITERATURE

Aspects of Porcine Somatotropin and Swine Growth

Relationship of Exogenous Somatotropin to Endogenous Growth Hormone

Somatotropin is a protein secreted by the anterior pituitary gland. Endogenous somatotropin occurs in a 22 kDa form consisting of 191 amino acid residues. This compound is regulated by growth hormone releasing factor (GRF-stimulatory) and somatostatin (inhibitory). Exogenous administration of naturally derived somatotropin improves rate and efficiency of gain, reduces carcass fat and increases carcass protein (Campbell et al., 1989a).

Recombinantly derived somatotropin has been evaluated in many studies (Evock et al., 1988; Boyd et al., 1988; Kanis et al., 1990) with equal or improved responses for performance and carcass traits when compared to pituitary somatotropin. However, Boyd et al. (1988) used 21 kDa recombinant somatotropin (deleted amino acids in positions 32-46) in barrows and gilts and concluded that synthetically derived somatotropin was more effective in improving efficiency of gain, decreasing carcass lipid and increasing carcass protein than pituitary somatotropin.

Methods of Exogenous Somatotropin Administration

Growth promoters are widely used in the livestock industry. The National Cattleman's Association (1989) estimates that over 90% of the fat cattle slaughtered in the U.S. have been implanted with a growth promoter. Exogenous implants are administered beneath the skin in the ear of cattle and slowly release a hormonal compound into the bloodstream. Although porcine somatotropin is not approved for commercial use, a method of application that is similar to that employed commercially in the beef industry must be developed for producer acceptance.

Daily Injection. The primary method of administration in present studies is through daily intramuscular injections. This approach is effective in achieving improved performance and improved carcass composition when administered to hogs between 25 and 105 kg of live weight. Hogs treated with somatotropin in the growing phase (30-60 kg) and subsequently withdrawn from treatment until a slaughter weight endpoint of 90 kg have shown sustained improvement of performance and carcass parameters (Campbell et al., 1989b). This sustained improvement after withdrawal may help compensate for the labor intensiveness of daily injections by reducing the number of days that hogs are administered pST. Hagen et al. (1990) treated gilts with somatotropin for either 20 d or 40 d to determine the effects of duration of treatment. They found that average daily gain was not affected, but feed efficiency improved for gilts treated for 40 d. Bryan et al. (1990) used gilts with an initial body weight of 55 kg to determine the effects of an intermittent somatotropin dose (0, 2.5 mg, or 5 mg daily) over a 28-d period. The gilts treated on a continuous daily basis had higher daily gains and larger loin muscle areas than gilts treated daily during alternate weeks.

Implants. Studies involving the use of somatotropin implants in swine are limited. Knight et al. (1988) implanted barrows (70 kg) with implants which released the equivalent of 2 or 4 mg/d pST over a period of six weeks. Average daily gain and feed efficiency were improved when treated barrows were compared to controls; however, pST effects on carcass composition were not discussed.

Optimum Dosage Level. The level of porcine somatotropin which elicits the maximal response for swine performance and carcass traits is uncertain. Many experiments using porcine growth hormone have been conducted, but dosage levels are expressed in many different ways and somatotropin administered in various patterns. However, some studies have been conducted with the intent to determine the optimum dosage level. Evock et al. (1988) stated that somatotropin effects growth and metabolism differently which results in different maximal doses for performance and carcass characteristics. Seventy-two crossbred barrows were treated with pituitary or recombinant somatotropin (0 to 140 mg/kg body weight) to evaluate dosage level and somatotropin source effects. Evock et al. (1988) found that levels of 70 mg/kg body weight or less enhanced growth without adverse effects; however, mobility problems occurred with greater dosage levels. Boyd et al. (1986) treated pigs with somatotropin levels ranging from 0 to 200 mg/kg body weight and reported optimal levels for the following traits: average daily gain, 60 mg/kg body weight; feed efficiency, 120 mg/kg body weight and loin eye area, ~200 mg/kg body weight. Additionally, Boyd et al. (1986) noted that the maximal level for backfat reduction was not achieved. Unlike the previous study, no mobility problems were encountered. Etherton et al. (1987) used 70 mg/kg body weight somatotropin or less to determine dosage level effects and concluded that feed

efficiency and carcass chemical components had not reached optimization at the level of 70 mg/kg body weight. Beermann et al. (1988) reported growth optimization at 60 mg/kg and carcass composition maximization at 90 mg/kg. Therefore, it appears that average daily gain may be maximized at approximately 60 - 70 mg/kg body weight. However, the optimal level for maximal carcass modification remains uncertain.

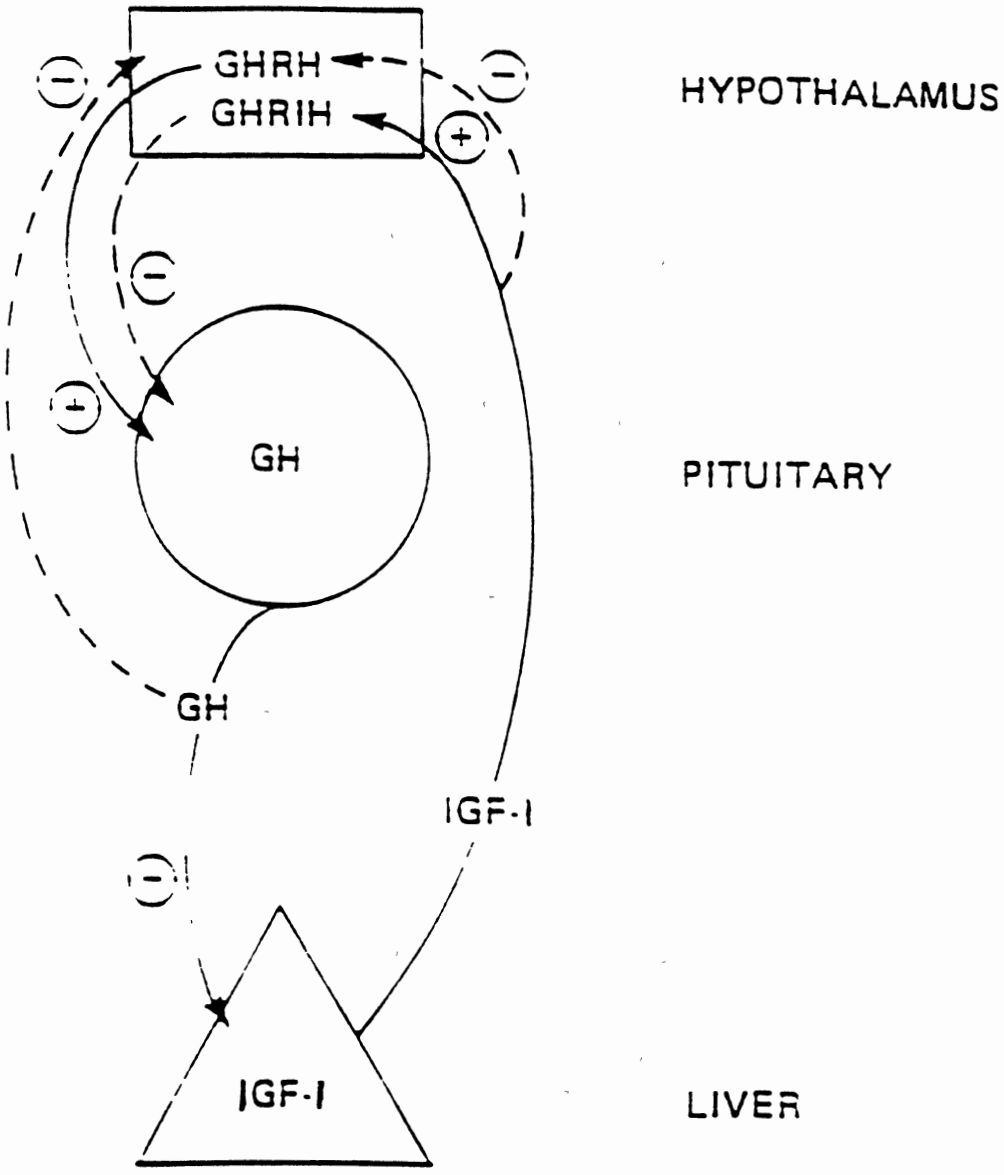
Mode of Action for Growth

Hormones Involved in Growth. The components involved in growth are numerous and diverse in actions. It is beyond the scope of this paper to discuss all of the many hormones and factors affecting growth; therefore, only factors closely associated with porcine somatotropin will be addressed.

Growth hormone (somatotropin) is a single polypeptide comprised of 191 amino acids. Somatotropin is released by the anterior pituitary and regulated by a feedback system illustrated in Figure 1. Porcine growth hormone binds to protein receptor sites located in liver membranes (Louveau and Etherton, 1990). Protein synthesis, lipid metabolism, and carbohydrate metabolism are affected by growth hormone.

Insulin is a 2 chained polypeptide hormone that plays an integral role in metabolism. This hormone stimulates anabolic processes and inhibits catabolic actions. In swine, adipose and muscle tissues have receptors which are specific for insulin (Mills and Szczepaniak, 1990). Muscle protein synthesis is enhanced by insulin as it increases amino acid uptake. Likewise, protein degradation is deterred by this hormone. Insulin also has an anabolic effect on fat as it stimulates lipogenesis and inhibits lipolysis.

FIGURE 1. Feedback system regulating growth hormone release[a]



[a] Adapted from Granner (1985). GHRH= Growth hormone-releasing hormone; GHRIH= Growth hormone release-inhibiting hormone.

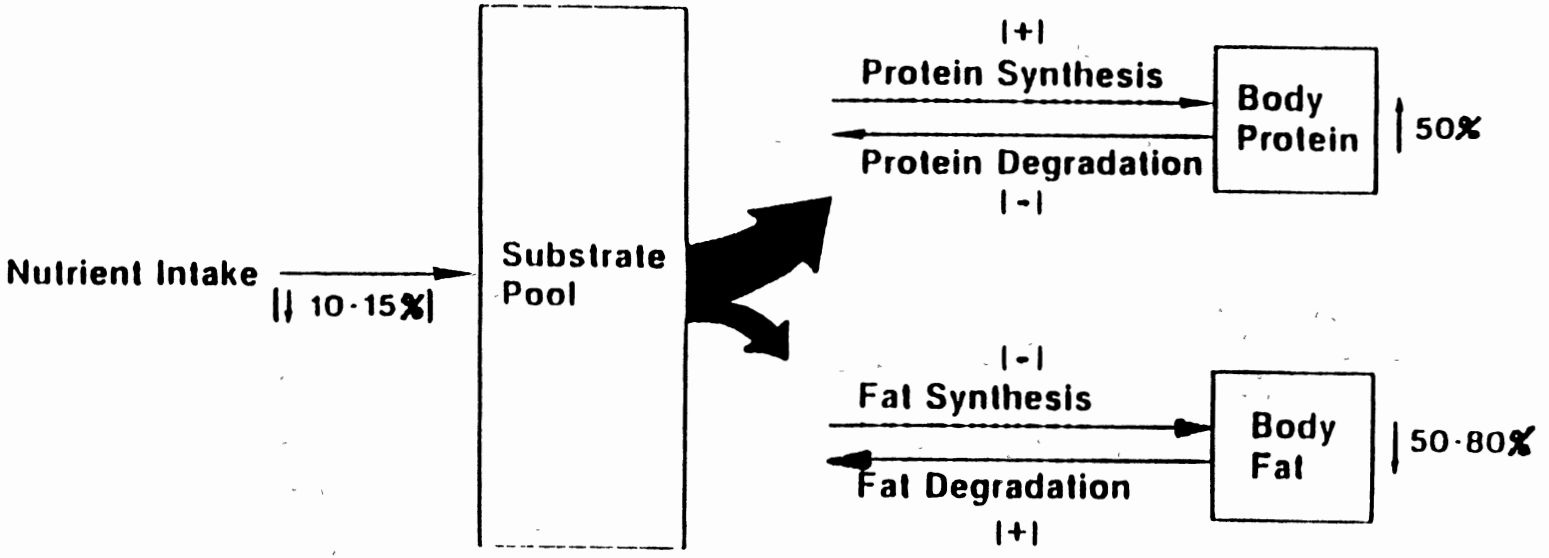
Insulin-like growth factors (IGF-I and IGF-II) are similar to insulin in structure as 50% of their residues are identical (Granner, 1985). IGF-I and IGF-II are single chain polypeptide hormones that are important factors in the stimulation of growth. IGF-I (Somatomedin C) , located in liver and skeletal muscle, is regulated by growth hormone and influences skeletal muscle growth (Grant et al., 1990). Somatomedin C inhibits growth hormone-releasing hormone (GHRH) and stimulates the release of somatostatin (GHRIH). IGF-I concentration increases in the postnatal pig; however, IGF-II, located in many different tissues, maintains its highest concentration throughout the fetal and neonatal life of the pig (Lee et al., 1990). Buonomo and Baile (1988) reported that IGF-II concentrations are highest between 3 and 5 months of age in pigs.

Probable Mode of Action for Porcine Somatotropin

Apparently, somatotropin partitions nutrients so that protein deposition is increased and lipid accretion is decreased (Machlin, 1972; Chung et al., 1985; and Evock et al., 1988). Figure 2 illustrates the partitioning of nutrients in swine. However, the precise mechanism by which somatotropin exerts its influence is difficult to explain. Glucose utilization, satellite cell proliferation, insulin action, and somatomedin concentration are all regulated by growth hormone (Etherton, 1989b).

Glucose Utilization. Glucose is the primary source of carbon for fatty acid synthesis and adipose tissue is the main site of fatty acid synthesis in the pig (O'Hea and Leveille, 1969). Therefore, glucose is a principal source of energy for lipid synthesis by adipose tissue. Blood glucose levels in pigs have been shown to increase in somatotropin treated hogs(Azain et al., 1988). In contrast, Kraft et al. (1986) treated hogs with recombinant somatotropin and found no increase

FIGURE 2. The effects of treating pigs with porcine growth hormone on nutrient partitioning[a]



[a]Adapted from Etherton (1989b).

in glucose levels. Consequently, a reduction in adipose tissue level by somatotropin allows glucose to be repartitioned to other tissues (Etherton, 1989b). Additionally, somatotropin treatment in pigs reduces glucose clearance rates and increases hepatic glucose production (Gopinanth and Etherton, 1988)

Insulin Action. Swine adipose tissue is sensitive to insulin and direct antagonism by pST results in reduced lipogenic rates as well as a partitioning of nutrients away from adipose tissue towards muscle (Walton and Etherton, 1986). Pituitary-derived and recombinantly derived growth hormone are equally effective in antagonizing insulin action (Walton et al., 1986). Unfortunately, the precise mechanism of pGH effects is uncertain. Possible methods of action include: 1) receptor level insulin recognition 2) enzymes that affect swine adipose tissue 3) glucose transport inhibition. Growing pigs treated with exogenous somatotropin have a lower rate of lipogenesis and reduced lipogenic enzyme activity (Magri et al., 1987). The effect that somatotropin has on lipogenesis may be due in part to a reduction of the pig's sensitivity to insulin (Wray-Cahen et al., 1990).

Somatomedin Concentration. IGF-I inhibits myofibrillar protein degradation and increases the rate of protein synthesis (Etherton, 1989a). Satellite cells, only visible with an electron microscope, are present between the sarcolemma and basement membrane of muscle fibers. These cells proliferate and fuse into existing muscle fibers. It appears that IGF-I stimulates the proliferation of satellite cells (Allen, 1989). Somatomedin treatment alone has been suggested as a possible means of growth stimulation; however, IGF-I does not exert the same effects as somatotropin on adipose tissue. IGF-I is bound to binding proteins (IGF-BP) of either 40 kDa or 150 kDa. Porcine serum treated with [^{125}I]-IGF reveals that approximately 40% of the labeled IGF-I is bound to

the 40 kDa binding protein and very little is bound to the larger binding protein indicating that endogenous IGF-I occupies the majority of the binding sites on the larger protein (Walton, 1988). However, Evock et al. (1990) evaluated IGF-I and IGF-II concentrations in IGF-BP and discovered that a majority of [^{125}]IGF-II added to pig serum binds to the 150 kDa IGF-BP complex and only a small proportion of [^{125}]IGF-I bound to the larger complex. Grant et al. (1990) found that administration of recombinant porcine somatotropin increased IGF-I mRNA in liver, but not in longissimus muscle. Unbound IGF-I stimulates lipogenesis and glucose oxidation in adipose tissue as does insulin (Etherton, 1988). This suggests that somatotropin effects on adipose tissue are direct and not stimulated indirectly by exogenous IGF-I.

Effect on Rate and Efficiency of Growth

Effects of Administration During the Growing Phase

Evans et al. (1988) treated pigs with somatotropin from 5 to 15 weeks of age to determine the effects on performance and carcass composition. Results indicated that loin eye area was increased (P=.05) 15.4 % with treatment and performance was not affected. Evock et al. (1988) found that hogs (initial weight of 27 kg) treated with pituitary porcine growth hormone, recombinant porcine growth hormone, and controls had similar average daily gain (ADG) and feed efficiency (F/G) during the first 5-6 weeks of treatment; however, at 6 weeks somatotropin treated hogs began to show improved gains and more efficient feed utilization than controls. Campbell et al. (1989b) discovered that barrows treated with pituitary growth hormone between 30 and 60 kg grew faster and more efficiently than controls. Additional support is provided by Chung et al. (1985) and Campbell et al. (1988); these researchers found that ADG and F/G

improved in barrows treated with somatotropin starting at approximately 30 kg live weight.

Effects of Administration During the Finishing Phase

Kanis et al. (1990) examined the effects of somatotropin administration to barrows and gilts between 60 and 140 kg live weight. Kanis found that average daily gain and feed efficiency were improved with treatment. Additional improvement was noted between 100 and 140 kg live weight. Campbell et al. (1989a) treated boars, barrows, and gilts with somatotropin and found that average daily gain and feed efficiency were improved for each sex-class when compared to control hogs. Somatotropin treatment improves growth performance in the finishing phase of growth as well as the growing phase. Table 1 presents a composite of somatotropin effects on growth performance for both phases of growth in pigs.

Effect of Nutritional Level and Administration of Porcine Somatotropin

The beneficial effects of porcine somatotropin may be affected by factors such as energy and nutritional levels of the diet. Beermann et al. (1990) evaluated hogs treated with somatotropin and fed diets containing various levels of protein and concluded that daily protein requirements were not increased by somatotropin. Evidence is provided by increased loin area and *semitendinosus* weight in pigs receiving somatotropin with no protein level interactions. Campbell et al. (1988) reported that increased energy intake increases growth rate, protein and fat accretion, carcass fat content and reduces protein and water amounts. Results also indicated that pGH increased maintenance energy

TABLE 1. DAILY GAIN AND FEED EFFICIENCY OF PIGS IN RESPONSE TO DAILY SOMATOTROPIN TREATMENT.[a]

Dosage Level	Phase of treatment	Number/ Sex-class[b]	Daily gain response[c]	Feed/gain response[c]	Source
100 mg/kg BW (pST)	25-55 kg	36; Ba	+16%	+23%	Campbell et al., 1988
100 mg/kg BW (pST)	30-60 kg	28; Ba	+36%	+28%	Campbell et al., 1989b
100 mg/kg BW (pST)	60 kg (31d)[d]	45; B, Ba, G	B Ba G +13%, +22%, +16%	B Ba G +19%, +34%, +32%	Campbell et al., 1989a
22 mg/kg BW (pST)	32 kg (30d)[d]	24; Ba	+10%	+4%	Chung et al.,1985
10, 30, 70 mg/kg BW (pST)	50 kg (35d)[d]	48; Ba	10 30 70 +9%, +6%, +14%	10 30 70 +7%, +10%, +17%	Etherton et al., 1987
35, 70 mg/kg BW (pST)	27 kg (77d)[d]	72; Ba	35 70 +15%, +11%	35 70 +15%, +24%	Evock et al., 1988
35, 70, 140 mg/kg BW (rpST)	27 kg (77d)[d]	72; Ba	35 70 140 +11%, +19%, +13%	35 70 140 +12%, +21%, +24%	Evock et al., 1988
14 mg (rpST)	60-100 or 140 kg	96; Ba, G	100 140 +5%, +20%	100 140 +8%, +14%	Kanis et al., 1989

[a] pST= pituitary-derived porcine somatotropin; rpST= recombinantly-derived porcine somatotropin.
[b] B= boar, Ba= barrow, G= gilt.
[c] + = Percentage increase in daily gain; percentage decrease in feed required per unit of gain.
[d] d= duration of treatment.

requirements and that pGH exerted its benefits independently of energy intake. Somatotropin increases feed efficiency and protein gain. Increasing the density of the diet fed treated pigs does not improve protein gain; however, feed efficiency is enhanced (Jewell and Knight, 1990).

Effect of Porcine Somatotropin on Carcass Traits

Effect of Porcine Somatotropin on Carcass Composition

Fat Thickness. Exogenous somatotropin treatment in pigs results in improvements in carcass fat and muscle levels (Table 2). The most dramatic improvements are noted in reduced fat levels in treated hogs. Average backfat thickness was reduced by 20 to 30 % in barrows treated with somatotropin between 30-60 kg live weight when compared to controls (Campbell et al., 1989b). Evock et al. (1988) recorded decreased fat thickness for last lumbar vertebra (44%), last rib (50%) and first rib (22%) in hogs treated with porcine growth hormone. Additional fat reductions were presented by Baile et al. (1990); dissected carcass fat was 12.6% for treated pigs and 18.5% for controls for a decrease of 25% ($P<.01$).

Muscling. Reports of porcine somatotropin effects on muscling traits are variable, possibly due to variations in dosage levels and/or duration of administration. Chung et al. (1985) treated hogs with 22 mg/kg body weight for a period of 30 d and found no significant increase in loin eye area; however, absolute weight of the loin was increased ($P<.05$) by growth hormone. Moreover, somatotropin increases ($P<.05$) the percentage of carcass weight as ham, loin and picnic shoulder (Thiel et al., 1989). Boyd et al. (1986) administered porcine growth hormone (0-200 mg/kg body weight) to forty-six crossbred hogs

TABLE 2. BACKFAT THICKNESS AND LOIN EYE AREA OF PIGS IN RESPONSE TO DAILY SOMATOTROPIN TREATMENT.[a]

Dosage Level	Phase of treatment	Number/ Sex-class[b]	Backfat thickness[c]	Loin eye area[c]	Source
100 mg/kg BW (pST)	25-55 kg	36; Ba	-24%	+13%	Campbell et al., 1988
100 mg/kg BW (pST)	30-60 kg	28; Ba	-30%	+16%	Campbell et al., 1989b
100 mg/kg BW (pST)	60 kg (31d)[d]	45; B, Ba, G	B Ba G 0%, -38%, -45%	-----	Campbell et al., 1989a
22 mg/kg BW (pST)	32 kg (30d)[d]	24; Ba	+4%	+2%	Chung et al.,1985
10, 30, 70 mg/kg BW (pST)	50 kg (35d)[d]	48; Ba	10 30 70 0%, -8%, -13%	10 30 70 +5%, +14%, +23%	Etherton et al., 1987
35, 70 mg/kg BW (pST)	27 kg (77d)[d]	72; Ba	35 70 -8%, -58%[e]	35 70 +21%, +29%	Evock et al., 1988
35, 70, 140 mg/kg BW (rpST)	27 kg (77d)[d]	72; Ba	35 70 140 -17%, -29%, -50%[e]	35 70 140 +25%, +21%, +46%	Evock et al., 1988
14 mg (rpST)	60-100 or 140 kg	96; Ba, G	100 140 -14%,-23%	-----	Kanis et al., 1989

[a] pST= pituitary-derived porcine somatotropin; rpST= recombinantly-derived porcine somatotropin.
[b] B= boar, Ba= barrow, G= gilt.
[c] -= Percentage decrease in average backfat thickness; + = Percentage increase in loin eye area or average backfat thickness.
[d] d= duration of treatment.
[e] Percentage decrease in last rib fat thickness.

to determine effects of somatotropin on lean deposition. They found that loin eye area (cm^2) increased ($P<.05$) 12.1% in comparison to controls. Additionally, Boyd et al. (1986) reported a 5.2 % increase ($P<.01$) in percent muscle. Carcass dissection results show that somatotropin increases the proportion of lean tissue in pork carcasses (Baile et al., 1990; Kanis et al. 1990 and Evock et al., 1988).

Bone and Skin. Somatotropin facilitates bone growth by stimulation of chondrocyte proliferation in the epiphyseal plate (Boyd and Bauman, 1989). However, data presenting the effects of porcine growth hormone on bone development are limited. Bark et al. (1990) found that porcine somatotropin (70 mg) increased ($P<.01$) the weight (kg) of bone as well as skin when compared to controls.

Effects on Meat Quality

The effects of somatotropin on pork palatability were examined by Beermann et al. (1988). Results indicated that somatotropin reduced ($P<.01$) intramuscular lipid concentration, but had no effect on palatability. Kanis et al. (1988) reported that somatotropin did not effect lean tenderness or flavor; however, lean color had a less intense red color than controls. Evock et al. (1988) found that pituitary somatotropin administered at the level of 70 mg/kg body weight significantly ($P<.05$) reduced marbling, texture and tenderness ; however, firmness, color, flavor and juiciness were not ($P>.05$) adversely affected by treatment.

Cooking properties have been evaluated by several researchers. Beermann et al. (1988) reported no cooking loss associated with somatotropin dose. Cooking time (min. to 75°C/100 g raw chop) and cooking loss were

evaluated by Gardner et al. (1989) and no differences were noted between treated and control hogs.

Effects on Carcass Chemical Composition

In a composite of 5 trials (n=744), hogs treated with somatotropin (0-5 mg/hd/d) had increased (P<.01) carcass protein (13.9 %) and reduced (P<.01) carcass fat (37.4 %) with increasing pST level (Baldwin et al., 1990). Etherton et al. (1986) treated eight Yorkshire-Duroc barrows (50 kg) with 30 μg/kg body weight for a period of 30 d and slaughtered the animals at 80 kg to compare carcass traits and composition with controls (n=8). They found that muscle mass (kg), protein (%), and water (%) were increased (P<.05) 35.5%, 8.2%, and 7.4%, respectively. In addition, the percentage of carcass lipid was reduced 18.2% (P<.05). Carcass chemical composition of boars, barrows, and gilts is affected by porcine growth hormone. Campbell et al. (1989) found that porcine somatotropin reduced (p<.01) and increased (P<.01) protein for all three sex-classes. Also, treatment eliminated sex-class differences in body composition. Additional support for somatotropin effects was reported by Evock et al. (1988); absolute muscle, protein (%), ash(%) and water (%) were increased (P<.05) and absolute adipose tissue and lipid (%) were reduced (P<.05) with growth hormone treatment. Table 3 presents results from various experiments involving porcine somatotropin and carcass chemical components. Somatotropin may affect wholesale cuts in a selective manner. McKeith et al. (1988) evaluated boneless cuts [ham (IMPS 401), loin (IMPS 410), belly (IMPS 408), and shoulder (IMPS 405 and IMPS 406)] from control (n=8) and somatotropin treated (n=8) hogs and discovered that lipid (%) was reduced 28-52% by treatment in all cuts (P<.05).

TABLE 3. CARCASS CHEMICAL COMPOSITION OF PIGS IN RESPONSE TO DAILY SOMATOTROPIN TREATMENT.[a]

Dosage Level	Phase of treatment	Number/ Sex-class[b]	Carcass lipid (%)[c]	Carcass protein[c]	Source
100 mg/kg BW (pST)	25-55 kg	36; Ba	-29%	+11%	Campbell et al., 1988
100 mg/kg BW (pST)	30-60 kg	28; Ba	-33%	+6%	Campbell et al., 1989b
100 mg/kg BW (pST)	60 kg (31d)[d]	45; B, Ba, G	B Ba G -23%, -35%, -34%	B Ba G +7%, +15%, +19%	Campbell et al., 1989a
10, 30, 70 mg/kg BW (pST)	50 kg (35d)[d]	48; Ba	10 30 70 0%, -15%, -25%	10 30 70 +1%, +11%, +13%	Etherton et al., 1987
35, 70 mg/kg BW (pST)	27 kg (77d)[d]	72; Ba	35 70 -27%, -54%[e]	35 70 +16%, +29%	Evock et al., 1988
35, 70, 140 mg/kg BW (rpST)	27 kg (77d)[d]	72; Ba	35 70 140 -30%, -32%, -68%[e]	35 70 140 +19%, +23%, +37%	Evock et al., 1988

[a] pST= pituitary-derived porcine somatotropin; rpST= recombinantly-derived porcine somatotropin.
[b] B= boar, Ba= barrow, G= gilt.
[c] -= Percentage decrease in carcass lipid (%); + = Percentage increase in carcass protein (%).
[d] d= duration of treatment.

CHAPTER III

EFFECTS OF RECOMBINANT PORCINE SOMATOTROPIN (rpST) AND SEX-CLASS ON SWINE SLAUGHTER TRAITS AND CARCASS QUALITY

ABSTRACT

Thirty hogs (barrows=15, gilts=15) were used to assess the effects of rpST and sex-class on slaughter traits and pork carcass quality. The hogs were assigned to one of five rpST treatment levels: 1=control, 2=.71 mg/d, 3=1.43 mg/d, 4=2.86 mg/d, 5=4.29 mg/d. Recombinant porcine somatotropin was administered by intramuscular injection. Barrows and gilts were fed a 14% crude protein diet and slaughtered upon attaining 104 kg of live weight. The left side of each carcass was used for quality and yield grade data collection. No differences (P>.05) for slaughter traits were noted between sex-classes; however, treatment with rpST increased (P<.05) cooler shrinkage. The amounts of carcass fat and lean were inversely affected by rpST treatment and sex-class. Total fat and 10th rib fat depth were reduced (P<.05). Additionally, gilts had less (P<.05) fat over the last rib. Fat free muscle (FFM%) and four lean cut weight (FLCW) was increased (P<.05) by treatment as well as sex-class. Gilts were longer (P<.001) and had more desirable (P<.05) USDA cutability grades than barrows. Cooking properties were not affected by treatment or sex-class. However, rpST did reduce (P<.05) the loin eye marbling score. Loin muscle color, firmness and tenderness was not affected (P>.05). Overall, rpST treatment and sex-class increased muscling and reduced carcass fat levels without affecting muscle cooking properties or tenderness.

(Key Words): Somatotropin, Sex-class, Slaughter Traits, Carcass Traits.

Introduction

Presently, means of rapidly altering pork carcass composition are limited. However, exogenous porcine somatotropin (pST) and recombinant porcine somatotropin (rpST) exhibit a potential for improving slaughter and carcass traits of swine (Machlin, 1972; Chung et al., 1985; Etherton et al., 1986; Campbell et al., 1988). Campbell et al. (1989a) and Kanis et al. (1990) found an inverse relationship between protein accretion and fat deposition particularly with an increase in slaughter weight. The absence of an increase in feed intake suggests that porcine somatotropin exerts its influence through repartitioning of nutrients.

The effects of somatotropin on cooking traits of pork have been minimal. Beermann et al. (1988) and Kanis et al. (1988) reported that cooking loss, drip loss, and tenderness were similar for somatotropin-treated and control hogs.

Previous porcine somatotropin studies have been primarily concerned with modes of action and production traits such as average daily gain and feed efficiency (Chung et al. 1985, Walton et al. 1986, Sillence and Etherton 1987). Additionally, experiments addressing the effects of pST and rpST on slaughter and carcass traits for both barrows and gilts are limited (Campbell, 1989; Kanis, 1990) and many have examined only singular dosage levels. Therefore, the intent of this trial was to examine the effects of various dosage levels (mg/d) of rpST on slaughter traits, carcass composition and cooking characteristics of barrows and gilts.

Materials and Methods

Animals. Thirty crossbred hogs (gilts, n=15; barrows, n=15) were allocated into 5 rpST treatment groups. Treatment 1 served as the control group and received 0 mg/d rpST, whereas treatments 2-5 were administered recombinant porcine somatotropin (mg/d) as .71, 1.43, 2.86 and 4.29, respectively. Hogs were fed a 14% crude protein diet (Table 1) and slaughtered at a live weight endpoint of 104 kg.

Slaughter data. The swine were transported approximately 400 kilometers to the Oklahoma State University Meats Laboratory and individually weighed upon arrival. Slaughter data collected included: slaughter weight, hot carcass weight, liver weight, intestinal weight (gastrointestinal contents included), dressing percentage, cold carcass weight, and cooler shrinkage.

Carcass data. Carcasses were chilled at 0°C. Twenty-four h postmortem, experienced University personnel obtained chilled carcass weight and ribbed the left side of each carcass between the 10th and 11th rib to collect USDA quality and yield grade data. Subcutaneous fat thickness was measured at the 10th-11th rib interface perpendicular to the outer skin surface at a point three-fourths the distance of the longissimus muscle from the vertebral column. Additional measurements collected included: loin eye area, muscle color (5=dark red, 4=red-pink, 3=light pink, 2=gray, 1=white/pale), marbling score (5=abundant, 4=moderate, 3=small, 2=slight, 1=traces) and muscle firmness (3=firm, 2=intermediate, 1=soft and watery) according to NPPC guidelines (NPPC, 1985). The left side of each carcass was further processed to obtain trimmed weights (.64 cm subcutaneous fat trim) of the ham, loin, Boston butt and picnic shoulder. The percentage of these cuts (four lean cuts) was determined on a left side weight basis. Left side components were further separated into lean, inseparable lean, fat (subcutaneous + intermuscular), bone and skin components.

Proximate analysis. In order to calculate the percentage of fat free muscle (FFM%), lean lipid and inseparable lean lipid amounts were determined by ether extraction. The proximate analysis procedure used for ether extraction was a modification of AOAC (1984) guidelines and was performed in triplicate. Each sample (3g) was placed in a glass thimble containing a non-absorbent cotton plug and a second cotton plug was placed on top of the sample before drying in a 103°C oven for 24 h to determine lipid content by ether extraction. After drying, each sample was cooled in a desiccator and then reweighed. Samples were then placed in a soxhlet apparatus for 24 h. At the end of this period, the samples were removed and ether was allowed to evaporate. The samples were then dried in a 103°C oven for 12 h and reweighed to determine lipid content. The combined lipid weight for the lean and inseparable lean aggregates (total muscle lipid) was divided by the combined lean and inseparable lean weight (total muscle weight) to determine the percentage of muscle lipid. The FFM% was calculated: [(total muscle - total muscle lipid)/ left side weight (LSW)] x 100. Total fat was derived for the left sides by combining the weights of subcutaneous fat, intermuscular fat and total muscle lipid. The percentage of total fat was calculated as total fat/LSW

Cooking properties. Two loin chops (2.54 cm thick) were removed from the tenth rib region 72 h postmortem to assess cooking characteristics and tenderness (AMSA, 1978). The chops were vacuum packaged and subsequently frozen at -30°C until cooking data could be collected. Chops were thawed (2°C) for 24 h, weighed and then broiled on Faberware® Open-Hearth broilers to an internal temperature of 75°C. The internal temperature was monitored using an Omega® OM-302 Temperature Logger. Cooked loin chops were weighed and cooled to 25° C at which time 6 cores (1.27 cm in diameter) were drilled from each chop to objectively determine tenderness. The force required to shear each

core was measured in kilograms by an Instron machine (model 1122). Cooking shrinkage (%) was calculated as [(raw weight - cooked weight)/raw weight] x 100. Cooking time was calculated as the time in minutes required to obtain an internal temperature of 75°C per 100g of raw boneless loin chop.

Statistical analysis: All data were analyzed using a model that included the effects of treatment, sex-class and the treatment x sex-class interaction. There were no (P>.05) treatment x sex-class interactions; consequently, only treatment and sex-class main effect means are presented. Least squares means were partitioned to contrast individual treatment level with the control group. Dunnett's procedure (Steel and Torrie, 1980) was used to test contrasts.

Results

Slaughter weight, hot carcass weight and dressing percentage were similar for all treatment groups and sex-classes (Tables 2 and 3). However, least squares means for cooler shrinkage (%) were increased with rpST dosage possibly due to a reduction of fat and an increase in muscle. Additionally, tendencies (P<.10) were noted for reduced cold carcass weight and increased liver weight with somatotropin treatment. No significant slaughter trait differences were noted for sex-class effects, but intestinal weight tended (P<.10) to be greater for gilts than for barrows.

Tables 4 and 5 present the carcass quality and cutability parameters examined. The weight of trimmed ham, loin, Boston butt, and picnic shoulder increased (P<.05) and tenth rib fat depth and marbling decreased (P<.05) with rpST dosage. Carcasses from hogs treated with 2.86 and 4.29 mg/d rpST had increased (P<.01) FFM% and decreased (P<.01) total fat in comparison to controls. Also, the average backfat thickness tended (P<.10) to decrease with rpST treatment and to be less for gilt carcasses. Gilt carcasses were longer

(P<.001), more desirable (P<.05) in USDA cutability grade and had reduced (P<.05) last rib fat thickness, tenth rib fat depth and total fat compared to barrows. Additionally, FFM% and weight of the four lean cuts were greater in gilt carcasses.

Cooking characteristics were examined (Tables 6 and 7) for rpST treatment and sex-class. However, no differences (P>.05) were observed for cooking time, cooking shrinkage and Instron shear force values.

Discussion

Administration of rpST to barrows and gilts at ascending dosage levels (.71-4.29 mg/d), increased the amount of carcass weight loss due to chilling. This weight loss would have a detrimental economic impact if similar results were observed in carcasses from treated hogs slaughtered under commercial conditions. Slaughter traits did not differ for barrows and gilts.

When carcass traits were partitioned by rpST dosage, improvements were noted for fat and muscling indicators. The amount of fat measured at the 3/4 mark of the 10-11th rib interface was reduced with rpST treatment, and when control hogs were contrasted with hogs treated with 2.86 mg/d a decrease (P<.05) was noted. Additional reductions in fat were observed for the amount of total fat contained in carcasses from hogs treated with 2.86 and 4.29 mg rpST/d. Etherton et al. (1989) postulates that in pigs fed ad libitum , fat reduction is a result of reduced lipid synthesis mediated by pST. Campbell et al. (1989a) attributed reduced fat accretion to increased protein deposition which reduces the energy available for lipid synthesis. Sex-class effects resulted in a reduction of last rib and tenth rib fat thickness as well as a decrease in total fat when comparing gilts to barrows. Kanis et al. (1990) reported similar carcass trait improvements for gilts compared to barrows.

Recombinant porcine somatotropin increases the amount of lean produced in carcasses from treated animals (Etherton et al., 1986; Evock et al., 1988). Although the loin eye areas were similar for carcasses from treated and non-treated hogs, the amount of FFM% increased with rpST treatment (2.86 and 4.29 mg/d). The weight of the trimmed wholesale cuts (ham, loin, Boston butt and picnic shoulder) was increased with rpST treatment. In a previous experiment, exogenous porcine somatotropin administered daily to barrows produced increased amounts of ham, loin and picnic shoulder (Thiel et al., 1989). These muscling improvements indicate that somatotropin does increase the proportion of saleable lean produced in treated carcasses. Gilts had longer carcasses with greater FFM%, more desirable USDA cutability grades and greater four lean cut weight than barrows.

Pork quality evaluations resulted in lower marbling scores for carcasses treated with somatotropin. Control hogs had greater marbling scores than hogs treated with 2.86 mg/d. The latter is indicative of reduced fat deposition. Evock et al. (1988) reported decreased ($P<.05$) marbling in loin chops from carcasses treated with porcine growth hormone; however, muscle firmness and color, were not different ($P>.05$). In contrast, lean color differences have been reported (Kanis, 1988). Quality parameters were similar for barrows and gilts. Cooking time, cooking shrinkage and tenderness were not adversely affected by rpST treatment or sex-class.

Implications

This experiment gives further indication that rpST administration in swine results in the production of trimmer and leaner carcasses. The optimal dosage level of rpST is still in question; however, the level of 1.43-2.86 mg/d provided beneficial effects in this study. In conclusion, recombinant porcine somatotropin increases carcass lean and decreases fat without adversely effecting the quality and tenderness of lean.

TABLE 1. RATION COMPOSITION

Ingredient	Percent of Diet
Yellow corn, ground	77.3
Soybean meal (48%)	17.0
Animal and vegetable fat	3.7
Dicalcium phosphate	.59
Limestone	.80
Trace minerals	.10
Salt	.04
Vitamins	.05
Choline chloride	.07
Selenium	.05
Calculated Composition (as fed basis)	
Crude protein, %	14.0
Calcium, %	.55
Phosphorus, %	.44
Lysine, %	.71

TABLE 2. SLAUGHTER TRAITS STRATIFIED BY PORCINE SOMATOTROPIN DOSAGE

Item	rpST dose mg/d					SE	P[a]
	0	.71	1.43	2.86	4.29		
Slaughter weight, kg	105.2	106.4	105.4	103.5	104.8	.78	.15
Hot carcass weight, kg	79.5	80.6	79.3	78.4	78.5	.62	.11
Dressing percentage	75.6	75.7	75.2	75.7	74.9	.31	.29
Cold carcass weight, kg	77.4	78.1	76.8	75.8	75.9	.64	.09
Cooler shrinkage, %	2.7	3.1	3.0	3.3	3.3	.15	.03
Liver weight, kg	1.5	1.6	1.8	1.7	1.8	.07	.06
Intestinal weight, kg[b]	7.4	7.6	8.2	7.7	8.0	.31	.39

[a]Probability of treatment effect.

[b]Intestinal weight includes the weight of the gastro-intestinal tract and contents.

TABLE 3. SLAUGHTER TRAITS STRATIFIED BY SEX-CLASS

Item	Sex-class		SE	P[a]
	Gilt	Barrow		
Slaughter weight, kg	105.4	104.7	1.10	.31
Hot carcass weight, kg	79.7	78.9	.87	.15
Dressing percentage	75.6	75.3	.44	.35
Cold carcass weight, kg	77.2	76.4	.91	.21
Cooler shrinkage, %	3.2	3.1	.21	.55
Liver Weight, kg	1.72	1.63	.10	.22
Intestinal weight, kg[b]	8.00	7.49	.44	.07

[a]Probability of sex-class effect.

[b]Intestinal weight includes the weight of the gastro-intestinal tract and contents.

TABLE 4. CARCASS TRAITS STRATIFIED BY PORCINE SOMATOTROPIN DOSAGE

Item	rpST dose, mg/d					SE	P[a]
	0	.71	1.43	2.86	4.29		
Carcass length, cm	80.9	80.3	81.2	82.2	82.3	.79	.34
Backfat thickness, cm							
Last rib	3.1	2.7	2.6	2.3	2.4	.20	.12
Average	4.0	3.5	3.3	3.0	3.2	.22	.09
3/4 fat depth (10th rib), cm	3.8	3.3	2.9	2.4*	2.6	.29	.02
Loin eye area, cm^2	32.7	32.0	32.2	34.3	32.9	1.69	.88
Muscle score[b]	1.7	2.3	1.8	2.2	2.0	.19	.17
Color[c]	2.7	2.7	2.8	2.8	2.5	.26	.89
Marbling[c]	2.7	2.0	1.7	1.5*	1.8	.23	.02
Firmness[c]	2.5	2.3	2.0	2.2	2.0	.21	.40
Fat free muscle, %	44.9	47.1	49.7	54.0*	53.1*	1.74	<.01
Total fat, kg	14.9	14.0	12.7	10.8*	10.8*	.75	<.01
Total fat, %	39.1	36.6	33.6	29.0*	29.0*	1.87	<.01
USDA cutability grade[d]	3.2	1.9	2.3	1.5	1.8	.47	.14
Four lean cut weight, kg[e]	22.0	23.4	23.4	24.0	23.5	.43	.04
Four lean cut weight, %	57.8	61.1	61.8	64.4*	63.1	1.18	.011

[a]Probability of treatment effect. Mean differs from that of negative control

* P<.05.

[b]Muscle scores: 1 = thin, 2 = intermediate.

[c]Loin eye scores: color: 2 = gray; marbling: 1 = traces, 2 = slight; firmness: 2 = intermediate.

[d]USDA, 1985.

[e]Weight of trimmed ham, loin, Boston butt, and picnic shoulder.

TABLE 5. CARCASS TRAITS STRATIFIED BY SEX-CLASS

Item	Sex-class		SE	P[a]
	Gilt	Barrow		
Carcass length, cm	82.8	80.0	1.12	<.001
Backfat thickness, cm				
Last rib	2.4	2.8	.29	.02
Average	3.2	3.6	.32	.07
3/4 fat depth (10th rib), cm	2.6	3.3	.41	.014
Loin eye area, cm^2	33.8	31.9	2.4	.22
Muscle score[b]	2.1	1.9	.27	.14
Color[c]	2.5	2.9	.38	.18
Marbling[c]	1.7	2.1	.33	.07
Firmness[c]	2.1	2.3	.29	.17
Fat free muscle, %	51.4	48.1	2.46	.04
Total fat, kg	11.9	13.4	1.07	.04
Total fat, %	31.4	35.5	2.65	.02
USDA cutability grade[d]	1.6	2.6	.66	.03
Four lean cut weight, kg[e]	23.8	22.8	.61	.015
Four lean cut weight, %	62.7	60.6	1.68	.06

[a]Probability of sex-class effect.

[b]Muscle scores: 1 = thin, 2 = intermediate.

[c]Loin eye scores: color: 2 = gray; marbling: 1 = traces, 2 = slight firmness: 2 = intermediate.

[d]USDA, 1985.

[e]Weight of trimmed ham, loin, Boston butt, and picnic shoulder.

TABLE 6. COOKING PROPERTIES AND SHEAR FORCE VALUES FOR LOIN CHOPS STRATIFIED BY PORCINE SOMATOTROPIN DOSAGE

	rpST dose, mg/d						
Item	0	.71	1.43	2.86	4.29	SE	P[a]
Cooking time, min.[b]	17.8	17.0	18.4	18.7	19.7	1.16	.55
Cooking shrinkage, %	31.2	31.2	33.6	31.1	35.8	1.52	.21
Instron shear force, kg	4.8	4.5	5.4	4.8	5.1	.29	.28

[a]Probability of treatment effect.

[b]Cooking time: (minutes to 75°C)/100g of raw boneless loin chop.

TABLE 7. COOKING PROPERTIES AND SHEAR FORCE VALUES FOR LOIN CHOPS STRATIFIED BY SEX-CLASS

	Sex-class			
Item	Gilt	Barrow	SE	P[a]
Cooking time, min.[b]	17.4	19.2	1.65	.09
Cooking shrinkage, %	33.2	32.8	2.15	.79
Instron shear force, kg	4.8	5.0	.41	.38

[a]Probability of sex-class effect.

[b]Cooking time: (minutes to 75°C)/100g of raw boneless loin chop.

CHAPTER IV

EFFECTS OF RECOMBINANT PORCINE SOMATOTROPIN (rpST) AND SEX-CLASS ON PORK CARCASS CHEMICAL COMPOSITION

ABSTRACT

Barrows (n=15) and gilts (n=15) were administered rpST by daily subcutaneous injection to assess effects on pork carcass chemical composition. The barrows and were equally allocated across five rpST treatment levels: 0=control, 0.71 mg/d, 1.43 mg/d, 2.86 mg/d, and 4.29 mg/d. Slaughter traits and carcass quality and yield grade data were previously reported by Gardner et al. (1990). The left side of each carcass was physically separated into lean, inseparable lean, fat, bone and skin components 48 h postmortem. Proximate analysis was performed in triplicate for each tissue group. The percentage of carcass as lean tissue was increased ($P<.05$) by rpST treatment. Fat tissue was decreased in hogs treated with rpST ($P<.01$) and was less ($P<.05$) in gilts than barrows. Somatotropin treatment increased ($P<.01$) the amount of soft tissue moisture (5-19%) and ash (7-22%) and reduced lipid (7.5-31%). Likewise, gilts had higher tissue moisture ($P<.01$), protein ($P<.05$) and ash ($P<.05$) coupled with lower ($P<.05$) lipid levels than barrows. The protein/lipid ratio was improved by somatotropin treatment and was more desirable for tissue obtained from gilt carcasses. Femurs and 10th rib bones were analyzed with few differences noted. Gilts and rpST treated barrows had increased carcass lean and protein levels as well as reduced fat tissue and lipid levels.

(Key Words): Somatotropin, Sex-class, Proximate Analysis.

Introduction

The amount of fat contained in the daily diet, particularly, meat is a primary concern of today's nutrition conscious consumer. Current guidelines suggest that no more than 30% of the daily caloric intake come from fat and only 10% of the level should be comprised of saturated fats. Exogenous porcine somatotropin (pST) treatment has been shown to reduce saturated fatty acids by 46% in lean tissue and by 36% in subcutaneous fat (Solomon et al., 1990).

Exogenous porcine somatotropin and recombinant porcine somatotropin (rpST) have exhibited desirable effects on swine slaughter and carcass traits (Machlin, 1972; Beermann et al., 1988; Baile et al., 1990). The effects of pST and rpST on carcass tissue chemical composition have been tested in several studies. Campbell et al. (1989) reported a 33% reduction in carcass lipid and a 6% increase in carcass protein. Recombinant porcine somatotropin was evaluated by Evock et al. (1988) who found that carcass lipid decreased 30-68% and protein increased 19-37% when rpST treatment was compared to a control.

Although many studies have been conducted on carcass chemical composition, several of these trials addressed only a singular dosage level or sex-class. The purpose of this experiment was to examine the effects of multiple dosage levels of rpST and sex-class on pork carcass tissue chemical composition.

Materials and Methods

Soft tissue, femur and tenth rib bone chemical composition analyses from hogs treated with recombinant porcine somatotropin are presented. The design of the study, slaughter, carcass grade and cookery data were described previously by Gardner et al. (1990). Briefly, 15 gilts and 15 barrows were

allocated across 5 treatment groups and administered recombinant porcine somatotropin (rpST) as follows: 0 (control), .71,1.43, 2.86, 4.29 mg/d respectively.

Tissue components. The left side of each carcass was physically separated into lean, inseparable lean, fat, bone and skin components 48 h postmortem. Each soft tissue composite was weighed and subsequently ground individually through a .95 cm plate. Samples were ground a second time through a .32 cm plate at which time .45 kg aggregates were randomly collected. The samples were then frozen at -30°C. Each frozen composite sample from the respective tissue groups was portioned into cubes using a band saw (Biro®, model 3334), immersed in liquid nitrogen and powdered in a Waring® Commercial Blendor (Model 34B122). Powdered samples were placed in Whirlpack® bags and stored at -30°C until proximate analysis was completed.

Proximate Analysis. Tissue samples were analyzed in triplicate following AOAC (1984) recommended guidelines. Powdered samples (3g) were placed on ashless filter paper and dried at 100°C for 24 h and desiccated for 1 h. Moisture content was then determined by reweighing the samples. Following moisture determination, samples were placed in glass thimbles containing non-absorbent cotton. The thimbles were then placed in a soxhlet for 24 h to determine lipid content by ether extraction. Afterwards, samples were dried at 100°C for 12 h, desiccated and reweighed to calculate lipid content. Ash content was determined after the remaining sample was held in a 650°C oven for 8 h. Protein content of an additional .5g powdered sample from each composite was determined using a KJELTEC® 1030 Auto Analyzer. Femur and 10th rib bones were denuded of all remaining external tissue, cubed as previously described and individually vacuum packaged and stored at -30°C. The cubed samples were immersed in liquid nitrogen and pulverized (Bel-Art® Micro Mill, model 372520000) until powdered. Previously outlined proximate analysis procedures

were performed in triplicate for rib and femur aggregates.

A model including the effects of treatment, sex-class and the treatment x sex-class interaction was used for statistical analysis of the data (SAS,1986). Least squares means were determined for each treatment level and sex-class. Dunnett's procedure (Steel and Torrie, 1980) was used to determine statistical differences between treatment groups and the control.

Results and Discussion

Carcass components. Soft tissue groups, femur and tenth rib bone means are presented for porcine somatotropin treatment and sex-class in Tables 1 and 2. There was no treatment x sex-class interaction; therefore, means are not reported. Somatotropin increased (P<.05) weight and percentage of lean in pork carcasses from hogs treated with 2.86 mg/rpST/d when compared to the other treatment levels. Previous experiments have produced similar values for lean tissue (Baile et al., 1990; Kanis et al., 1990). Additional improvement in carcass composition was evidenced by a reduction (P<.01) in carcass fat tissue (kg and %) for treatment levels of 2.86 and 4.29 mg/rpST/d. Baile et al. (1990) reported a 25% decrease in dissected fat for pigs treated with 3 mg PST. Inseparable lean values were not affected (P<.05) by rpST treatment. Comparison of barrow and gilt carcasses indicated that gilts had less fat (P<.05) and more (P<.05) inseparable lean (kg) than barrows. Carcass bone (femur and 10th rib) and skin was not affected (P>.05) by rpST treatment or sex-class. However, Bark et al. (1990) reported that pigs treated with 70μg PST had increased (P<.01) bone and skin weights.

Soft tissue chemical composition. Proximate analyses of soft tissue components were performed and the results were partitioned by somatotropin dose and sex-class. The weights and percentages of protein, moisture, lipid and

ash as well as protein/water ratios and protein/lipid ratios are presented for each of the five treatment groups in Tables 3 and 4. The lean tissue aggregate had increased (P<.05) moisture when comparing lean tissue from hogs receiving 2.86 mg/d and controls. Solomon et al. (1990) reported that lean tissue from hogs treated with 100 mg/kg/d pST contained 27% less lipid than tissue from control hogs; however, in this study, lean tissue lipid content was not affected (P>.05) by somatotropin treatment. Carcasses from hogs treated with 2.86 and 4.29 mg/d had 38% and 35% less (P<.05) lipid in fat tissue compared to fat tissue obtained from controls. However, moisture was increased (P<.05) in fat tissue from hogs treated with 2.86 mg/d. Total weights and percentages of protein, moisture, lipid and ash were calculated for the combined soft tissue groups. Protein (%) was increased (P<.05) when pooled treatment means were compared to the control; however, Dunnett's procedure did not detect a significant difference between an individual treatment group and the control. Baile et al. (1990) found a 7% improvement (P<.01) in soft tissue protein levels when hogs were treated with 3 mg PST/d. The rpST level of 2.86 mg/d reduced (P<.05) carcass lipid 31% and increased (P<.05) ash 22% in comparison to controls. Total moisture levels from carcasses treated with 2.86 and 4.29 mg/d were higher (P<.05) than levels in tissues from control hogs. Protein levels were compared to water and lipid levels. The protein/lipid ratio was more greater (P<.05) for tissue from hogs treated with 2.86 mg/d compared to controls.

Sex-class effects on soft tissue chemical composition are listed in Tables 5 and 6. Lean tissue from gilts had less (P<.05) lipid and more (P<.01) moisture than barrows. The kilograms of protein in inseparable lean and fat was greater (P<.05) in gilts than in barrows and when protein was calculated as a percentage of left side weight, gilts tended (P<.10) to have a higher percentage than barrows. The percentage of protein, moisture and ash was greater in the fat tissue of gilts

(P<.05). Additionally, lipid (%) was less (P<.01) in gilt fat tissue. Soft tissue composite chemical composition results show that protein and moisture were both 10% greater (P<.05) in tissue from gilts than from barrows. Total lipid present in soft tissue from gilts was 16% less (P<.05). The ratio of protein to water was the same for both barrows and gilts. However, the protein/lipid ratio was increased (P<.01) in gilt carcass tissue.

Proximate analysis of bone. The chemical composition of the femur and tenth rib bone were evaluated and the results are listed in Tables 7 and 8. The only difference observed for femurs from treated hogs and controls was an increase (P<.01) in grams of moisture for the levels of 2.86 and 4.29 mg/d. Tenth rib bones from carcasses of hogs treated with 4.29 mg/d rpST possessed 12% less ash than controls. Sex-class had no effect (P>.05) on tenth rib bone composition. Gilts did have less (P<.01) moisture and higher (P<.05) lipid levels in the femur than barrows.

Implications

The results of this study indicate that rpST has a positive effect on improvement of carcass soft tissue components and their respective composition. Lean tissue was increased by as much as 22% and separable fat was reduced by as much as 30%. Additionally, chemical composition of carcass tissue was improved by rpST as evidenced by reductions in ether extractable lipid and more desirable protein/lipid ratios. These findings in addition to previously reported improvements in carcass grade and yield traits indicate that porcine somatotropin aids in producing leaner hogs with desirable composition characteristics.

TABLE 1. CARCASS COMPONENTS STRATIFIED BY PORCINE SOMATOTROPIN DOSAGE[a]

Item	rpST dose, mg/d					SE	P[b]
	0	.71	1.43	2.86	4.29		
Left side weight, kg	38.1	38.4	37.8	37.3	37.3	.33	.11
Lean, kg	12.2	13.1	13.7	14.5*	13.9	.49	.02
IS Lean[c], kg	6.9	7.1	7.0	7.5	7.6	.29	.37
Fat, kg	12.9	12.0	10.8	8.9*	9.1*	.71	<.01
Bone, kg	4.1	4.2	4.3	4.4	4.4	.12	.36
Skin, kg	1.8	1.7	1.9	1.9	2.0	.07	.22
Lean, %	32.0	34.1	36.4	39.0*	37.4	1.34	.011
IS Lean, %	18.2	18.4	18.5	20.2	20.4	.79	.17
Fat, %	33.9	31.2	28.4	23.8*	24.3*	1.79	<.01
Bone, %	10.7	10.9	11.3	11.7	11.7	.32	.12
Skin, %	4.8	4.6	5.0	5.1	5.4	.21	.09

[a]Calculated on a left side basis.

[b]Probability of treatment effect. Mean differs from that of negative control

* P<.05.

[c]IS Lean = Inseparable lean and fat.

TABLE 2. CARCASS COMPONENTS STRATIFIED BY SEX-CLASS[a]

Item	Sex-class		SE	P[b]
	Gilt	Barrow		
Left side weight, kg	37.9	37.6	0.47	.20
Lean, kg	13.9	13.1	0.69	.08
IS Lean[c], kg	7.5	6.9	0.41	.04
Fat, kg	10.1	11.4	1.01	.054
Bone, kg	4.3	4.2	0.17	.14
Skin, kg	1.9	1.8	0.11	.051
Lean, %	36.6	34.9	1.89	.17
IS Lean, %	19.8	18.5	1.12	.08
Fat, %	26.4	30.2	2.53	.02
Bone, %	11.4	11.1	0.46	.28
Skin, %	5.1	4.8	0.29	.08

[a]Calculated on a left side basis.

[b]Probability of sex-class effect.

[c]IS Lean = Inseparable lean and fat.

TABLE 3. KILOGRAMS OF SOFT TISSUE PROTEIN, LIPID, MOISTURE AND ASH STRATIFIED BY PORCINE SOMATOTROPIN DOSAGE[a]

Item	rpST dose, mg/d					SE	P[b]
	0	.71	1.43	2.86	4.29		
Lean:							
protein	2.53	2.68	2.86	2.95	2.84	.10	.10
lipid	.63	.72	.73	.77	.63	.07	.55
moisture	8.77	9.45	10.00	10.62*	10.24	.37	.018
ash	.13	.14	.15	.16	.15	.005	.018
IS Lean[c]:							
protein	1.16	1.17	1.20	1.32	1.29	.06	.24
lipid	1.38	1.34	1.23	1.17	1.13	.11	.51
moisture	4.12	4.26	4.29	4.72	4.81	.25	.26
ash	.06	.06	.06	.07	.07	.003	.30
Fat:							
protein	.42	.43	.43	.43	.40	.03	.96
lipid	10.91	9.93	8.72	6.79*	7.13*	.74	<.01
moisture	1.25	1.30	1.34	1.14	1.29	.05	.17
ash	.02	.02	.02	.02	.02	.001	.18
Total:							
protein	4.12	4.28	4.49	4.70	4.54	.14	.08
lipid	12.92	11.99	10.68	8.73*	8.89*	.79	<.01
moisture	14.14	15.02	15.62	16.47*	16.34	.48	.016
ash	.206	.222	.231	.244*	.236	.007	.02
Protein/H_2O ratio	.29	.28	.28	.28	.27	0.003	.22
Protein/Lipid ratio	.35	.36	.43	.55*	.52	0.03	<.01

[a]Calculated on a left side basis.

[b]Probability of treatment effect. Mean differs from that of negative control

* P<.05.

[c]IS Lean = Inseparable lean and fat.

TABLE 4. KILOGRAMS OF SOFT TISSUE PROTEIN, LIPID MOISTURE AND ASH STRATIFIED BY SEX-CLASS[a]

Item	Sex-class		SE	P[b]
	Gilt	Barrow		
Lean:				
protein	2.86	2.69	.16	.11
lipid	.64	.75	.10	.11
moisture	10.15	9.47	.52	.052
ash	.15	.14	.008	.08
IS Lean[c]				
protein	1.29	1.16	.08	.017
lipid	1.24	1.26	.16	.87
moisture	4.66	4.22	.36	.06
ash	.07	.06	.005	.14
Fat:				
protein	.45	.40	.04	.08
lipid	7.89	9.50	1.05	.02
moisture	1.33	1.20	.07	.02
ash	.02	.02	.001	.94
Total:				
protein	4.60	4.25	.20	.013
lipid	9.78	11.51	1.12	.02
moisture	16.15	14.90	.69	<.01
ash	.24	.22	.01	.03
Protein/H_2O ratio	.28	.28	.005	.91
Protein/Lipid ratio	.50	.39	.05	<.01

[a]Calculated on a left side basis.

[b]Probability of sex-class effect.

[c]IS Lean = Inseparable lean and fat.

TABLE 5. PROXIMATE ANALYSES OF SOFT TISSUE COMPONENTS STRATIFIED BY PORCINE SOMATOTROPIN DOSAGE[a]

Item	rpST dose, mg/d					SE	P[b]
	0	.71	1.43	2.86	4.29		
Lean:							
protein %	20.84	20.48	20.82	20.34	20.4	.21	.37
lipid %	5.23	5.54	5.34	5.32	4.5	.55	.73
moisture %	72.04	72.20	72.78	73.01	73.49*	.26	<.01
ash %	1.04	1.06	1.07	1.08	1.07	.01	.24
IS Lean[c]:							
protein %	16.66	16.53	17.11	17.51	16.97	.35	.34
lipid %	20.01	19.02	17.73	15.62	15.37	1.67	.24
moisture %	59.24	60.38	61.01	62.72	62.94	1.41	.32
ash %	.85	.87	.88	.91	.90	.02	.53
Fat:							
protein %	3.45	3.61	4.02	5.09	4.53	.49	.16
lipid %	83.49	82.92	81.06	75.78	78.26	1.95	.056
moisture %	10.37	10.96	12.43	13.29	14.58*	.82	.011
ash %	.17	.18	.20	.21	.21	.01	.10
Total:							
protein %	10.82	11.15	11.90	12.62	12.18	.40	.03
lipid %	33.83	31.29	28.25	23.42*	23.86	2.00	<.01
moisture %	37.19	39.14	41.34	44.23*	43.87*	1.34	<.01
ash %	.54	.58	.61	.66*	.64	.02	.01

[a]Calculated on a left side basis.

[b]Probability of treatment effect. Mean differs from that of negative control

* P<.05.

[c]IS Lean = Inseparable lean and fat.

TABLE 6. PROXIMATE ANALYSES OF SOFT TISSUE COMPONENTS STRATIFIED BY SEX-CLASS[a]

Item	Sex-class		SE	P[b]
	Gilt	Barrow		
Lean:				
protein %	20.6	20.6	.31	.80
lipid %	4.6	5.8	.79	.02
moisture %	73.2	72.3	.36	<.01
ash %	1.07	1.06	.01	.43
IS Lean[c]:				
protein %	17.2	16.7	.49	.08
lipid %	16.6	18.5	2.36	.22
moisture %	62.0	60.5	1.99	.24
ash %	.89	.88	.03	.75
Fat:				
protein %	4.7	3.6	.70	.017
lipid %	77.4	83.3	2.76	<.01
moisture %	13.8	10.9	1.16	<.01
ash %	.21	.18	.02	.02
Total:				
protein %	12.1	11.3	.57	.03
lipid %	25.7	30.6	2.83	.012
moisture %	42.6	39.7	1.90	.02
ash %	.62	.59	.02	.09

[a]Calculated on a left side basis.

[b]Probability of sex-class effect.

[c]IS Lean = Inseparable lean and fat.

TABLE 7. WEIGHT AND PROXIMATE ANALYSES OF FEMUR AND RIB BONES STRATIFIED BY PORCINE SOMATOTROPIN[a]

Item	rpST dose, mg/d					SE	P[b]
	0	.71	1.43	2.86	4.29		
Femur:							
weight, g	253.5	264.2	268.3	281.1	272.1	7.44	.15
protein, g	41.0	43.2	45.1	45.2	43.9	1.17	.12
moisture, g	73.8	76.0	80.6	88.5**	84.7*	2.17	<.01
lipid, g	51.0	49.5	49.2	56.0	53.8	4.40	.77
ash, g	79.4	84.0	82.9	80.4	80.0	2.37	.60
protein, %	16.2	16.4	16.8	16.1	16.1	.46	.78
moisture, %	29.1	28.8	30.0	31.5	31.2	.62	.016
lipid, %	19.9	18.6	18.3	19.8	19.8	1.24	.81
ash, %	31.5	31.9	30.9	28.6	29.4	.79	.03
Rib:							
weight, g	28.5	26.6	27.7	26.7	28.3	1.37	.78
protein, g	5.9	5.8	6.0	5.7	6.0	.26	.89
moisture, g	9.9	9.5	9.7	10.0	10.7	.55	.56
lipid, g	1.9	1.7	1.5	1.7	2.2	.22	.27
ash, g	9.6	8.9	9.5	8.4	8.5	.47	.24
protein, %	20.9	21.7	21.7	21.4	21.1	.35	.41
moisture, %	34.8	35.7	35.0	37.4	38.1	.74	.016
lipid, %	6.6	6.5	5.5	6.5	7.9	.64	.18
ash, %	34.0	33.5	34.4	31.5	29.9*	.84	<.01

[a]Calculated on a left side basis.

[b]Probability of treatment effect. Mean differs from that of negative control

* P<.05; ** P<.01.

TABLE 8. WEIGHT AND PROXIMATE ANALYSES OF FEMUR AND RIB BONES STRATIFIED BY SEX-CLASS[a]

Item	Sex-class		SE	P[b]
	Gilt	Barrow		
Femur:				
weight, g	272.8	262.9	10.53	.15
protein, g	43.8	43.5	1.66	.77
moisture, g	79.6	81.8	3.08	.25
lipid, g	56.3	47.6	6.23	.03
ash, g	82.4	80.3	3.36	.33
protein, %	16.1	16.6	.65	.29
moisture, %	29.2	31.1	.87	<.01
lipid, %	20.5	18.1	1.76	.04
ash, %	30.3	30.6	1.11	.70
Rib:				
weight, g	28.0	27.1	1.94	.47
protein, g	6.0	5.7	.37	.26
moisture, g	10.2	9.8	.78	.40
lipid, g	1.7	1.9	.31	.36
ash, g	9.0	9.0	.66	.98
protein, %	21.5	21.2	.50	.44
moisture, %	36.3	36.0	1.04	.70
lipid, %	6.2	7.0	.91	.16
ash, %	32.1	33.2	1.19	.18

[a]Calculated on a left side basis.

[b]Probability of sex-class effect.

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APPENDIX

FAT FREE LEAN REGRESSION VALUES FOR BARROWS, GILTS, AND ALL SWINE

FIGURE 1. REGRESSION OF FAT FREE LEAN (%) ON PORCINE SOMATOTROPIN (rpST) DOSAGE FOR BARROWS

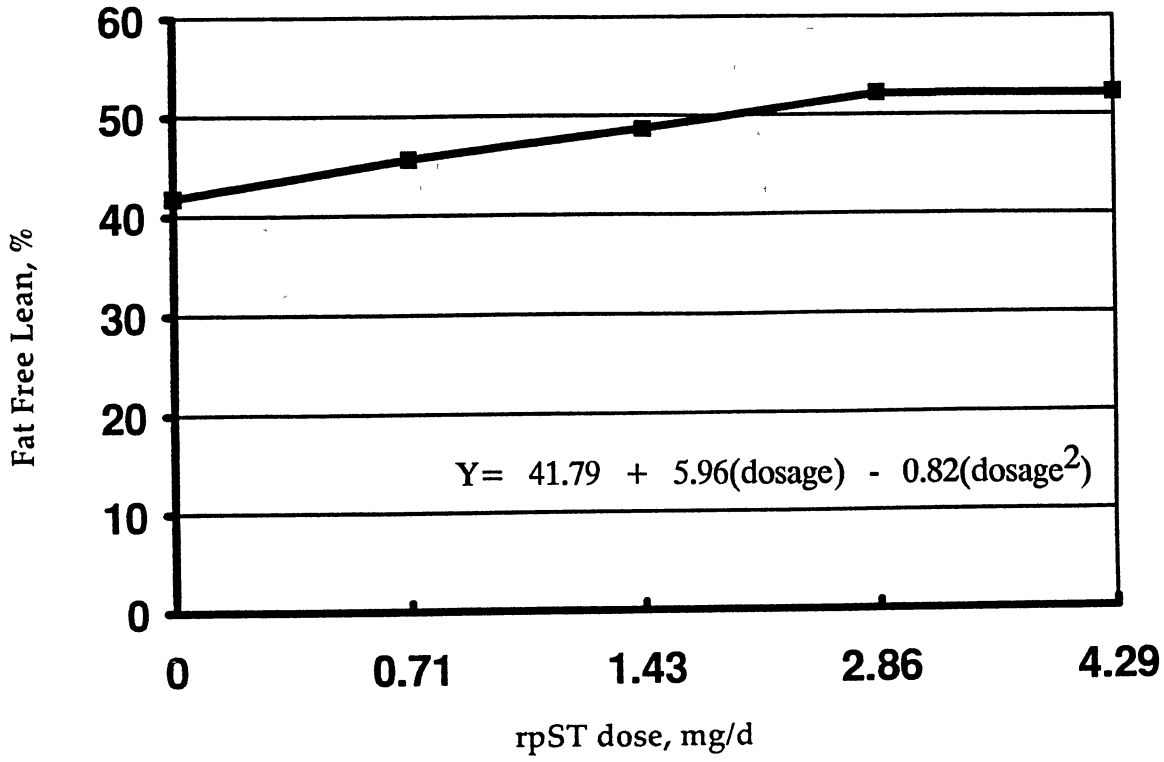


FIGURE 2. REGRESSION OF FAT FREE LEAN (%) ON PORCINE SOMATOTROPIN (rpST) DOSAGE FOR GILTS

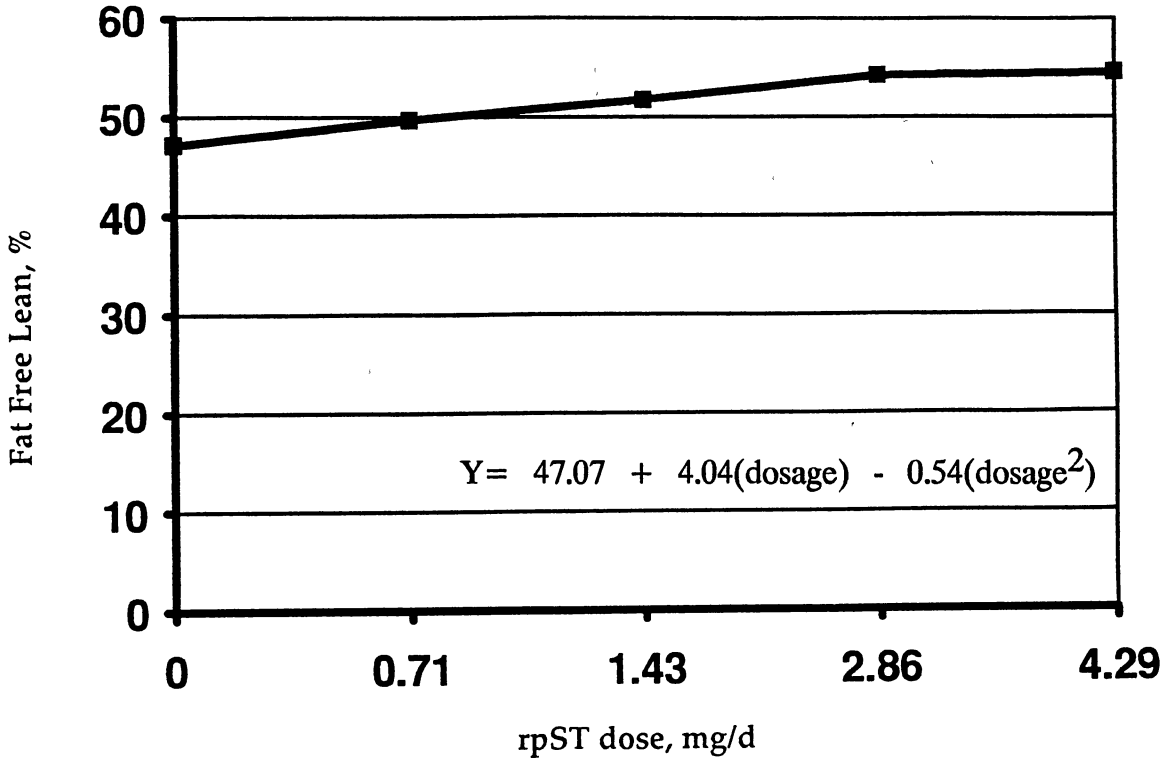
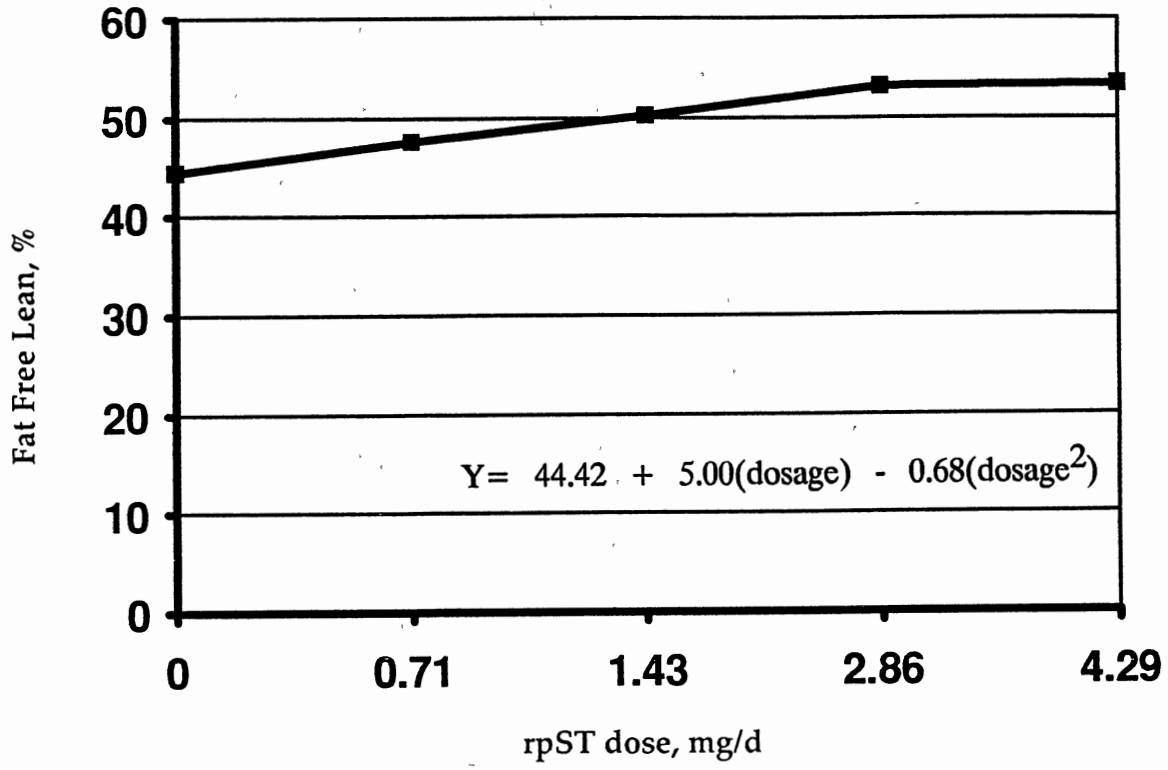


FIGURE 3. REGRESSION OF FAT FREE LEAN (%) ON PORCINE SOMATOTROPIN (rpST) DOSAGE FOR ALL SWINE



VITA

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Master of Science

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