OCCURRENCE OF GIANT FIBERS AND PALE, SOFT, EXUDATIVE (PSE) MUSCLE IN PIGS TREATED WITH PORCINE SOMATOTROPIN (pST)

M.B. SOLOMON[1], R.G. CAMPBELL[2], N.C. STEELE[3] AND T.J. CAPERNA[3]

U.S. Dept. of Agr., ARS, Beltsville, MD 20705 U.S.A.

[1]Meat Sci. Res. Lab., PQDI, U.S.A.
[2]Anim. Res. Inst., Weeribee, Victoria 3030, Australia
[3]Nonruminant Anim. Nutr. Lab., LPSI, U.S.A.

INTRODUCTION

Cassens et al. (1969) and Hendricks et al. (1971) characterized 'giant' muscle fibers as being nearly circular in shape and having a much larger diameter than other muscle fibers with an unusual histochemical staining pattern. Cassens et al. (1969) reported that giant fibers do not correspond to the classical fiber patterns, but often resemble fast twitch-glycolytic (W) fibers. Dutson et al. (1978) reported that the giant fibers found in their study resembled fast twitch-oxidative (I) fibers. In previous studies by Solomon and Eastridge (1987), Solomon and West (1985), Bader (1983) and Rahelic and Puac (1980), the giant fibers encountered resembled slow twitch-oxidative (R) and/or I fibers. The occurrence of giant muscle fibers has been associated with stress-susceptible pigs, which generally exhibit PSE muscle (Mircheva and Vitanov, 1987).

With greater emphasis on lean tissue deposition and less lipid in meat producing carcasses, several studies in our laboratory were conducted with designs to address the question of defining genetic potential for protein deposition in the pig and the resulting effects on muscle quality. Porcine somatotropin was used as a tool to maximize genetic potential for protein accretion.

MATERIALS AND METHODS

Three experiments were conducted to evaluate the effects of pST on porcine muscle growth and quality. In the first study (Expt. 1), 34 barrows were assigned to a 2 x 3 factorial treatment array at 25 kg live weight consisting of pST administration (USDA-pGH-B1; 0 and 100 ug/kg/d) and three levels of feed intake (FI) of a single diet (ad libitum [A], 1.64 kg/d [R1:80% of A] and 1.38 kg/d [R2:60% of A]) between 25 and 55 kg live weight. The experimental diet was formulated to contain 3.5 Mcal digestible energy (DE) and 3.4 g lysine:Mcal DE.

Pigs receiving pST were injected daily (IM) with pST which was solubilized in sterile bicarbonate buffer. Control pigs were injected daily with bicarbonate buffer. All animals were slaughtered at 55 kg body weight regardless of the length of time on treatment. Samples of the longissimus (LM) muscle from the 13th rib region were removed within 1.5 h postmortem and immediately restrained on flat sticks. Muscle samples were frozen in liquid nitrogen and subsequently stored at -70°C until histochemical analyses were performed. A 1 cm^3 of tissue was removed from each frozen sample and sectioned (12 um thick) using a cryostat-microtome. Sections were treated with the combination myofibrillar (acid) ATPase and succinate dehydrogenase staining procedure described by Solomon and Dunn (1988).

For the second study (Expt. 2), 37 Duroc x Yorkshire pigs were assigned at 60 kg body weight to a 2 x 3 factorial treatment array consisting of pST administration (0 and 100 ug/kg/d) and sex type (intact male = boar, female = gilt, castrate male = barrow). The experimental diet was formulated to contain 3.5 Mcal DE with a lysine:DE value 25% greater than the requirement of boars growing from 50 to 90 kg. The diet was fed ad libitum. Pigs receiving pST were injected daily (IM) with pST which was solubilized in sterile bicarbonate buffer. Control pigs

were injected daily with a comparable volume of bicarbonate buffer. All pigs were treated for 31 d and slaughtered on the 32 d of the experiment (avg. slaughter weight 97 kg). Longissimus muscles were sampled for histochemical analyses as described for Expt. 1.

For the third study (Expt.3), 23 barrows were used to investigate the effects of pST administration (0 and 100 ug/kg/d) between 30 and 60 kg on LM morphology of pigs grown to 90 kg. Administration of pST was by daily IM injection and pigs were fed a common diet in restricted amounts between 30 and 60 kg and ad libitum from 60 to 90 kg. Longissimus muscles were sampled for histochemical analyses as described for Expt. 1.

RESULTS

Expt. 1. Abnormally large (giant) fibers (Figure 1) were detected in the LM from all but one pig receiving pST from the R2 treatment group (Table 1). None were observed from the control pigs. There was no visual indication of PSE muscle from any of the treatment groups.

Expt. 2. Giant fibers were present in the LM from all but one boar and one gilt receiving pST (Table 2). Giant fibers were also present in one excipient boar and one excipient barrow. Two of 6 boars, 1 of 6 gilts and 2 of 6 barrows receiving pST displayed PSE muscle. None of the control pigs exhibited PSE muscle.

Expt. 3. All the pST treated pigs exhibited giant fibers in the LM muscle, regardless of the withdrawal period (Table 3). None were observed in the control pigs. A high proportion (62%) of pST treated pigs exhibited PSE muscle. None of the control pigs exhibited PSE muscle.

DISCUSSION

The giant fibers observed in these three studies were distinctly round and were found both at the periphery and toward the center of a fasciculus. Not every bundle contained giant fibers. These giant fibers possessed fiber properties similar to both R and I fibers in combination based on reactions to the staining procedure described by Solomon and Dunn (1988). Their characteristic size, shape and staining pattern enabled their recognition. The occurrence of giant muscle fibers in pigs has been associated with stress-susceptible pigs, which exhibit PSE muscle (Mircheva and Vitanov, 1987). Pale, soft, exudative muscle was assessed by visual color appraisal and 45 min postslaughter pH muscle (LM) measurements.

Results from the first experiment and the majority of pigs from the second experiment suggested that the giant fiber aberrations stimulated in occasional muscle fibers as described by Handel and Strickland (1986), which causes hypercontractile activity with the fibers and is associated with compensatory (flux) adaptations.

Pigs susceptible to stress and ultimately resulting in PSE muscle can generally be identified by a hyperthermic response to halothane. Halothane sensitivity was not determined on any of the pigs, therefore, it was not clear whether pigs treated with pST resulting in PSE muscle were stress sensitive/ malignant hyperthermic. Although it is not clear, it is possible that pST may have exaggerated a stress response in the pigs which resulted in PSE muscle. One additional observation was a possible seasonal effect in relation to pST administration. Expt. 3 and some of the pigs from Expt. 2 were involved in the experiment during the summer months which were extremely hot. Perhaps, there is a relationship between environment (e.g., temperature) and pST administration.

REFERENCES

Bader, R. (1987): Histological findings in skeletal muscles of pigs with different stress susceptibility. J. Vet. Med. 34:452.

Cassens, R.G., Cooper, C.C. & Briskey, E.J. (1969): The occurrence and histochemical characterization of giant fibers in the muscle of growing and adult animals. Acta Neuropathol. 12:300.

Dutson, T.R., Merkel, R.A., Pearson, A.M. & Gann, G.L. (1978): Structural characteristics of porcine skeletal muscle giant myofibers as observed by light and electron microscopy. J. Anim. Sci. 46:1212.

Handel, S.E. & Strickland, N.C. (1986): "Giant" muscle fibers in skeletal muscle of normal pigs. J. Comp. Pathol. 96:447.

Hendricks, H.B., Lafferty, D.T., Aberle, E.D., Judge, M.D. & Forrest, J.C. (1971): Relation of porcine muscle fiber type and size to postmortem shortening. J. Anim. Sci. 32:57.

Mircheva, T. & Vitanov, S. (1987): Histological and ultrastructural appearance of pale, soft pig meat and pale, soft, exudative pig meat. Veterinarnomeditsinski Nauki. 24:91.

Rahelic, S. & Puac, S. (1980): Relation of fiber types in six large muscles of pigs. Proc. 26th European Meeting of Meat Research Workers. p. 14. Colorado Springs, Colorado.

Solomon, M.B. & West, R.L. (1985): Profile of fiber types in muscles from wild pigs native to United States. Meat Sci. 13:247.

Solomon, M.B. & Eastridge, J.S. (1987): Occurrence of giant fibers from wild pigs native to the United States. Meat Sci. 20:75.

Solomon, M.B. & Dunn, M.C. (1988): Simultaneous histochemical determination of three fiber types in single sections of ovine, bovine, and porcine skeletal muscle. J. Anim. Sci. 66:255.

Table 1. Incidence of giant fibers in the longissimus muscle by pST and feed intake (Expt. 1)

Item	pST, ug/kg/d		Feed intake, kg/d[a]		
	0	100	A	R1	R2
No. of pigs	17	17	12	12	10
Giant fibers					
Number[b]	0	1.7	1.8	1.5	1.8
Area, um^2	NA	7634.1	6945.1	8019.5	7937.6

[a]A = Ad libitum; R1 = 1.64; R2 = 1.38 kg/day.

[b]Number of occurrences in an 8.8 x 12.5 cm area with a x58 magnification.

Table 2. Incidence of giant fibers and PSE in the longissimus muscle by pST and animal sex (Expt. 2)

Sex	pST dose (ug/kg/d)	Number of pigs	Giant fiber[a]		PSE[b]
			No.	Area (um^2)	
Intact male	0	7	.3	7247.5	0
	100	6	3.3	7146.9	2
Castrate male	0	6	.2	7441.7	0
	100	6	4.1	8466.3	2
Female	0	6	0	NA	0
	100	6	3.4	6971.4	1

[a]Number of occurrences in an 8.8 x 12.5 cm area with a x58 magnification.

[b]Number of pigs with PSE.

Table 3. Incidence of giant fibers and PSE in the longissimus muscle by pST treatment (Expt. 3)

Item	60 kg		90 kg	
	pST, ug/kg/d		pST, ug/kg/d	
	0	100	0	100
Number of pigs	4	4	6	9
Giant fibers[a]				
Number	0	2.1	0	2.8
Area, um^2	NA	7212.1	NA	8113.8
PSE[b]	0	3	0	5

[a]Number of occurrences in an 8.8 x 12.5 cm area with a x58 magnification.

[b]Number of pigs with PSE.

FIGURE 1. Cross-section of longissimus muscle (1.5 h postmortem) frozen section and reacted for the combination myofibrillar (acid) ATPase and succinate dehydrogenase staining procedure (x990). G denotes 'giant' fiber.