Tissue development in meishan pigs : muscle and fat development and metabolism and growth regulation by somatotropic hormone

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DEVELOPPEMENT TISSULAIRE CHEZ LE PORC DE RACE MEISHAN: DEVELOPPEMENT ET METABOLISME DES TISSUS MUSCULAIRE ET ADIPEUX ET REGULATION DE LA CROISSANCE PAR L'HORMONE SOMATOTROPE.

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Les porcs de race Meishan (MS) ont, comparativement aux porcs de type européen, une vitesse de croissance réduite et une teneur en dépôts adipeux élevée. Ils représentent par conséquent un modèle d'étude privilégié du développement tissulaire dans l'espèce porcine. Cet article rapporte les résultats obtenus récemment à la Station de Recherches Porcines sur ce thème; ils sont comparés à des données similaires pour des animaux de type européen, essentiellement dans la race Large White (LW).

Le niveau de consommation spontanée est comparable chez les porcs MS et LW lorsque leur poids vif est inférieur à 30 kg. Mais l'augmentation ultérieure du niveau d'ingestion est plus faible chez les animaux MS. La vitesse de croissance est également comparable pour les deux génotypes chez les jeunes animaux mais elle reste pratiquement constante jusqu'au poids vif de 100 kg chez les porcs MS (environ 450 g par jour) alors qu'elle s'accroit régulièrement jusqu'au poids vif de 70-80 kg dans les génotypes européens. Sur l'ensemble de la croissance, les teneurs en muscles, os, protéines et minéraux sont inférieures et les teneurs en tissus adipeux, peau et lipides supérieures chez les porcs MS. Les différences de vitesse de croissance et de composition corporelle entre les deux génotypes résultent essentiellement de la faiblesse de la croissance musculaire et du dépôt quotidien de protéines chez les porcs MS. Le gain quotidien de dépôts adipeux et de lipides est équivalent, voire inférieur, pour les animaux MS. Ce résultat est à associer à leur moindre niveau de consommation.

Le moindre potentiel de croissance musculaire des porcs MS existe dès la naissance puisqu'ils possèdent moins de fibres musculaires (-38% par rapport aux porcs LW). La moindre augmentation de l'aire de section transversale des fibres de type II chez les porcs MS accentue l'écart entre les deux génotypes. Dans le muscle des animaux MS, l'intensité du métabolisme oxydatif est plus élevée, tant à la naissance qu'ultérieurement alors que la moindre activité glycolytique se met en place après la naissance. A même poids vif, les adipocytes sont plus gros chez les porcs MS que les LW. Le potentiel de lipogénèse des animaux MS (estimé par l'activité spécifique des enzymes de la lipogénèse dans les tissus adipeux) tend à être plus faible, notamment vers 100 kg. Ce résultat est à rapprocher des données concernant les dépôts quotidiens de lipides et le niveau de consommation des porcs MS.

Les sécrétions spontanées de GH et d'IGF-I sont comparables chez les porcs LW et MS. Toutefois, la moindre réponse des animaux MS à une surcharge d'insuline suggère que la régulation de la sécrétion de GH diffère entre les deux génotypes. L'amélioration des performances de croissance associée à l'administration d'hormone somatotrope est inversement proportionnelle au potentiel de croissance de tissu maigre et est, par conséquent, plus élevée chez les animaux MS que ceux de type européen. L'action de la GH sur les tissus cibles ne semble donc pas entravée chez les porcs MS.

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TISSUE DEVELOPMENT IN MEISHAN PIGS: MUSCLE AND FAT DEVELOPMENT AND METABOLISM AND GROWTH HORMONE REGULATION BY SOMATOTROPIC HORMONE.

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Meishan (MS) pigs are known to exhibit poor growth and carcass performance, comparatively to European breeds. Therefore, they represent an interesting model for studies on tissue development in swine. In the present review, newly available results obtained at the Station de Recherches Porcines on that topic are presented and compared with those on European breeds, mostly of the pure Large White (LW).

Feed intake is similar in LW and MS in young animals (up to 30 kg live weight). Afterwards, the increase with weight in feed intake is slower in MS animals. Growth rate is also similar for the two breeds when the animals are young but it remains constant up to 100 kg live weight (about 450 g per day) in MS pigs while it increases steadily up to 70-80 kg liveweight in European breeds. Over the growing period, muscle, bone, protein, water and minerals contents are lower whereas fat, skin and lipids contents are higher in MS than in LW pigs. The difference in growth rate and body composition between the two breeds is mainly associated with a much lower daily protein and muscle deposition in MS animals. In connection with a lower feed intake, daily gain of lipids and adipose tissues is similar and even lower in the Chinese breed.

The lower potential for muscle growth of MS pigs is already present at birth via a reduced number of muscle fibers. The smaller postnatal increase in cross-sectional area of existing type II fibers in MS pigs further enhance the difference between the two breeds. The more oxydative metabolism of MS muscle is observed from birth onwards while the lower glycolytic activity is acquired during postnatal growth. At a given live weight, adipocytes are bigger in MS than in LW pigs. In agreement with the similar or even reduced daily lipid deposition in MS animals, their lipogenesis potential (as measured by specific activity of lipogenic enzymes in adipose tissues) tends to be lower, at least in 100 kg live weight pigs.

Spontaneous pGH and IGF-I secretions seem to be similar in MS and LW pigs. However, the blunted pGH response to insulin challenge in MS pigs suggest that the regulation of pGH release may differ between the two breeds. In response to exogenous porcine somatotropin, improvement in performance and carcass characteristics is in inverse proportion of the potentialities of the animals for muscle growth and, therefore, is more important in MS than in European breeds. These results suggest that the effect of pGH on target tissues does not seem to be impaired in MS pigs.

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INTRODUCTION

Meishan (MS) pigs are known to exhibit poor growth and carcass performance, comparatively to European breeds (ZHANG et al., 1983 ; XU ZHEN-YING, 1985 ; LEGAULT et al., 1985). In that respect, they represent an interesting model of low potentialities for lean tissue deposition in swine. However, the mechanisms responsible for the slow growth of muscle tissue and large development of adipose tissue are still poorly understood. A research programme has been initiated at the Station de Recherches Porcines in order to investigate muscle and fat development and metabolism as well as endocrine control of growth in MS pigs.

The aim of the present paper is to present the newly available results, most of them still unpublished, obtained within that programme. After a quick survey of growth performance of MS pigs, original data will be presented concerning muscle and adipose tissue development and metabolism and growth regulation by somatotropic hormones in MS animals, in comparison with European pigs, mostly of the pure Large White (LW) breed.

1) GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS.

MS pigs are lighter at birth than European animals and growth rate of piglets is at least 30% lower in MS than in LW during the suckling and post weaning periods (LEGAULT and CARITEZ, 1982). Feed intake is similar in LW and MS in young animals (less than 30 kg). Then, the increase with weight in feed intake is slower in MS than in LW and plateaus in MS castrates after 60 kg live weight (about 1.8 kg dry matter per day ; NOBLET and DUBOIS, 1990). Growth rate is constant and in the range of 0.40-0.45 kg/d between 15 kg and 100 kg body weight (BIDANEL et al., 1990; PRUNIER et al., 1990; NOBLET and DUBOIS, 1990).

The results of anatomical dissections conducted on MS and LW pigs, slaughtered at 80-90 Kg live weight (POILVET et al., 1990), demonstrated that muscle content in the carcass of MS animals is still lower than expected from crossbreeding experiments (30.5% in MS vs 47.3% in LW). In the other hand, fat and skin contents are much higher in MS than in LW (fat: 44.7% vs 31.8% ; skin 8.9% vs 3.2%). Bone content is similar in the two breeds (9.7-9.8%).

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2) TISSUE DEVELOPMENT AND CHANGES IN BODY CHEMICAL COMPOSITION DURING GROWTH.

In order to describe changes during growth in body composition, 12 MS castrates were slaughtered at regular intervals between 10 and 100 kg live weight. For each animal, one half carcass was dissected into the different tissues (muscle, fat, bones, skin). Chemical composition of the dissected tissues, head, visceral organs and blood were measured. Allometric relationships between weight of tissues or chemical constituents and empty body weight were calculated. The results are compared to similar data obtained in LW castrated males (KAREGE and NOBLET, unpublished data).

Table 1. Tissue development and changes in body chemical composition during growth in LW and MS pigs (NOBLET, unpublished).

EBW[1]	30		60		90		allometry coefficient	
genotype	MS	LW	MS	LW	MS	LW	MS	LW
Tissue composition (% of empty body weight)								
muscle	30.8	43.3	27.0	43.2	25.7	43.1	0.88	1.00
fat	18.8	13.5	31.2	20.3	37.7	25.7	1.46	1.59
skin	7.7	3.8	7.3	3.4	7.2	3.2	0.95	0.83
bone	8.7	10.2	6.8	8.5	6.2	7.7	0.78	0.79
Chemical composition (% of empty body weight)								
water	56.1	66.1	47.6	59.1	43.3	55.3	0.76	0.84
proteins	16.4	16.5	14.3	16.3	12.3	16.1	0.88	0.98
lipids	22.9	13.0	33.6	20.0	42.0	25.8	1.55	1.63
ashes	3.4	3.1	2.9	3.1	2.4	3.1	0.90	1.00
Daily gain (g)								
live weight	463	705	463	830	463	790		
muscle	113	289	106	340	102	322		
fat	145	144	204	254	250	306		
water	188	371	163	392	150	348		
proteins	66	108	44	126	32	118		
lipids	156	142	233	258	295	315		

[1] Empty body weight (about 95 % of live weight)

Over the growing period, muscle and bone contents were lower whereas fat and skin contents were higher in MS than in LW pigs (Table 1). Empty body weight gain between 20 and 100 kg live weight contained 24.1, 43.9, 7.0 and 5.5 % of muscles, fat, skin and bones in MS pigs, respectively . Corresponding values for LW castrates were 43.0, 30.8, 2.9 and 6.5 %. The difference in tissular composition between the two breeds increased with body weight for muscles and skin. With regard to adipose tissues, their relative growth was slower in MS than in LW animals (see allometry coefficients in table 1).

In agreement with data on tissular composition, body protein and ash contents were similar in the two breeds at 30 kg. However, they subsequently decreased sharply in MS whereas they remained rather

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constant in LW. The difference in lipid content between the two breeds increased from 9.9 % at 30 kg to 16.2 % at 90 kg. Empty body weight gain between 20 and 100 kg live weight contained 11 % proteins and 50 % lipids in MS vs 16 % proteins and 31 % lipids in LW.

Daily deposition of muscle was 2.6 and 3.2 fold lower in MS than in LW at 30 kg and 90 kg, respectively. Daily deposition of fat was similar in the two breeds at 30 kg and lower in MS than in LW at 60 or 90 kg. From 20 to 100 kg live weight MS pigs daily deposited 107 g muscles, 196 g adipose tissues, 48 g proteins and 223 g lipids (mean daily live weight gain: 460 g). Corresponding values in LW pigs were 302, 222, 116, 227 and 760 g.

The difference in growth rate and body composition between MS and LW pigs is associated with much lower protein accretion and muscle deposition in MS animals. On the other hand, daily depositions of fat and lipids are similar or even lower in MS than in LW pigs. This rather surprising result has to be associated with the low feed intake of MS pigs (see section 1).

3) MUSCLE FIBER AND ADIPOCYTE DEVELOPMENT.

3-1) Muscle fibers.

It is not presently known whether the lower capacity of MS pigs for muscle growth is related to a reduced number of muscle fibers (that is definitely fixed before birth in swine - STAUN, 1963 ; STICKLAND and GOLDSPINK, 1973), and/or to a smaller size of muscle fibers (that dramatically increases postnatally). Muscle histochemical and biochemical characteristics were compared in LW and MS pigs at birth (semitendinosus ; table 2) and in adults (longissimus dorsi ; Table 3). Fiber types were classified according to BROOKE and KAISER (1970).

Table 2. Histochemical traits and enzyme activities in semitendinosus muscle of LW and MS pigs at birth (LEFAUCHEUR, unpublished).

	LW	MS	Significance
Histochemical traits			
Red portion			
Nb of fibers (x 10^{-3})	192.5	127.5	***
Fiber types, %			
I	20.7	15.5	*
II	79.3	84.5	*
Mean fiber area, um^2	103	133	+
White portion			
Nb of fibers (x 10^{-3})	232.4	135.7	***
Fiber type, % II	100	100	NS
Fiber area, um^2	77	81	NS
Enzyme activities (mmole/min/g fresh muscle)			
Lactate Deshydrogenase	52.1	45.0	NS
Citrate synthase	10.7	12.2	***
Hydroxy-acyl-CoA deshydrogenase	7.3	8.3	***

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At birth, total number of muscle fibers was lower (-38 % ; P< .001)) in MS than in LW pigs while their mean cross sectional area tended to be higher (P < .06) in MS. Therefore, the smaller semitendinosus muscle size in MS animals at birth (1.61 vs 2.74 g in LW ; P < .001) is the result of the lower number of muscle fibers. MS pigs had a smaller proportion of type I fibers (P < .05) in the red portion of semitendinosus. Oxydative enzyme activities (CS and HAD) were higher in MS than in LW pigs (P < .001) while no difference between breeds was noticed for glycolytic enzyme (LDH). Relatively to muscular oxidative metabolism, our results suggest that MS piglets are more mature than LW at birth, in accordance with DARNTON et al. (1983) who compared 110 days obese and lean pig fetuses. However, the smaller proportion of type I fibers and the presence of numerous typical myotubes suggest a delayed differentiation of myofiber histochemical characteristics in MS animals.

LW adult pigs were heavier than MS animals (260 vs 184 kg ; P < .001) at similar ages (28.2 vs 25.6 months ; NS). Total number of fibers was higher in LW than in MS pigs (table 3). Percentages of the various fiber types did not differ between the two breeds. Cross-sectional areas of type I and IIa fibers were similar in the two breeds whereas type IIb fibers were larger in LW than in MS (7770 vs 4345 um^2 ; P < .01). Thus, both fiber number and size seem to contribute to the smaller LD area of MS pigs (20.0 cm^2 vs 45.2 cm^2 in LW). Oxydative enzyme activities (CS and HAD) were higher in MS than in LW pigs while the opposite was found for glycolytic enzyme (LDH). The higher oxydative and lower glycolytic potential of MS muscle is consistent with the higher relative area occupied by type I fibers (12.7% in MS vs 8.2% in LW ; P < .05). More oxydative metabolism in MS may reveal a larger utilization of lipid substrates, in accordance with the higher intramuscular fat content of MS animals (POILVET et al., 1990)

Table 3. Histochemical traits and enzyme activities in longissimus dorsi muscle of adult LW and MS pigs (LEFAUCHEUR, unpublished).

	LW	MS	Significance
Histochemical traits			
Nb of fibers (x 10^{-3})	669.5	446.0	*
Fiber type, %			
I	10.5	9.7	NS
IIA	6.0	5.8	NS
IIB	83.5	84.5	NS
Mean fiber area, um^2	7337	4137	*
Enzyme activities (mmole / min / g fresh muscle)			
Lactate Deshydrogenase	1758	1201	***
Citrate synthase	7.4	11.2	***
Hydroxyl-acyl-CoA deshydrogenase	2.6	4.0	***

In conclusion, the lower potential for muscle growth of MS pigs is already present at birth via a reduced number of muscle fibers. The smaller postnatal increase in cross-sectional area of existing type II fibers further enhance the difference between the two breeds. The more oxydative metabolism of MS muscle is observed from birth onwards while the lower glycolytic activity is acquired during postnatal growth.

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3-2) Adipocytes.

Adipocyte size was measured, at 100 kg live weight, in intact male, female and castrated male LW and MS pigs. Adipocyte size was determined, following osmic acid fixation, in back fat (at the level of 16th-17th ribs) and in ham intermuscular fat (between adductor femoris and semitendinosus muscles).

Table 4. Adipocyte mean diameters (um) in back fat and ham intermuscular fat of LW and MS pigs (MOUROT, unpublished)

Sex	Males		Females		Castrates	
Breed	LW	MS	LW	MS	LW	MS
Back fat	67.2	85.4	69.2	102.1	72.6	105.8
Ham inter-musc. fat	58.1	65.2	62.6	78.6	69.4	80.6

Adipocyte diameter was smaller in LW than in MS pigs ($P < .001$), the difference being more dramatic in backfat than in ham intermuscular fat (Table 4). In backfat, the difference in adipocyte size between LW and MS was larger in gilts and castrates than in males (sex x breed interaction: $P < .05$). Adipocyte volume was 2 fold larger in MS than in LW males and 3 fold larger in MS than in LW castrates and gilts. The bigger adipocytes in MS than in LW animals are consistent with the larger development of adipose tissue in MS pigs.

4) LIPOGENIC ENZYME ACTIVITIES IN ADIPOSE TISSUE.

Lipogenic enzyme activities were determined at 40 and 100 kg live weight in intact male, female and castrated male LW and MS pigs. Acetyl-CoA carboxylase (ACX), malic enzyme (ME) and glucose-6-phosphate deshydrogenase (G6PDH) were measured in backfat, ham subcutaneous fat, ham intermuscular fat and ham intramuscular fat (semitendinosus muscle). Activities are expressed per g tissue or per mg protein (specific activity).

ACX activities (as per g tissue) in subcutaneous and intermuscular fat tissues were higher at 40 than at 100 kg ($P < .001$) and lower in MS than in LW pigs ($P < .001$). ACX activities at 100 kg were 6, 10 and 7 fold smaller in MS than in LW for backfat, ham subcutaneous fat and ham intermuscular fat respectively. The decrease with weight in ACX activities is consistent with previous findings. In backfat, the lower ACX activity in MS animals was probably the result of the larger size of adipocytes since ACX specific activity (as per mg protein) did not differ between the two breeds (Table 5). In ham subcutaneous and intermuscular fats, ACX specific activities were similar in the two breeds at 40 kg, whereas they were lower in MS than in LW animals at 100 kg.

In intramuscular fat, ACX activities were lower in MS than in LW (2.1 vs 2.9 nmoles HCO_3^-/min/g tissue ; $P < .001$). However ACX specific activities (as per mg protein) were significantly higher in MS than in LW animals (Table 5).

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Table 5. Acetyl-CoA Carboxylase (ACX) activities at 40 and 100 kg in LW and MS pigs (MOUROT unpublished)

Sex		Males		Females		Castrates	
Breed		LW	CH	LW	CH	LW	CH
Specific activities (pmole HCO3-/min/mg protein)							
Back	40 Kg	40	41	39	41	42	46
fat	100 Kg	37	33	38	37	56	48
Ham subcu-	40 Kg	44	60	44	46	40	47
taneous fat	100 Kg	38	12	42	22	55	38
Ham inter-	40 Kg	34	34	30	34	38	38
musc. fat	100 Kg	17	4	43	7	32	8
Ham intra-	40 Kg	64	80	57	91	61	76
musc. fat	100 Kg	55	58	63	83	43	68

ME and G6PDH activities (as per g tissue) in subcutaneous and intermuscular fats decreased between 40 and 100 kg ($P < .001$). They were similar in the two breeds at 40 kg, whereas they were twice lower in MS than in LW at 100 kg. Therefore, the weight-related decline in ME and G6PDH activities was more dramatic in MS than in LW animals. The lower activities in 100 kg MS pigs were probably due to the larger size of adipocytes since ME and G6PDH specific activities (as per mg protein) were similar or higher in MS than in LW animals (table 6).

In intramuscular fat, ME activities increased between 40 and 100 kg in LW animals, whereas no weight-related change was observed for ME activities in MS pigs and G6PDH activities in both breeds. ME and G6PDH specific activities (as per mg protein) were significantly higher in MS than in LW pigs at 40 as well as at 100 kg.

Table 6. Malic enzyme (ME) activities at 40 and 100 kg in LW and MS pigs (MOUROT unpublished)

Sex		Males		Females		Castrates	
Breed		LW	CH	LW	CH	LW	CH
Specific activities (nmole NADPH/min/mg protein)							
Back	40 Kg	25	58	26	57	29	50
fat	100 Kg	41	35	32	64	42	59
Ham subcu-	40 Kg	30	62	24	63	23	52
taneous fat	100 Kg	29	33	31	52	37	50
Ham inter-	40 Kg	18	39	13	36	17	30
musc. fat	100 Kg	13	12	18	11	18	13
Ham intra-	40 Kg	6	12	5	15	7	15
musc. fat	100 Kg	10	13	9	16	10	16

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In conclusion, lipogenesis potential in subcutaneous and intermuscular adipose tissues (expressed by ACX specific activity) is similar in the two breeds at 40 kg and similar or lower in MS than in LW at 100 kg. The activities of NADPH producing enzymes (ME and G6PDH) are mostly higher in MS than in LW animals. The similar or lower potential for lipogenesis in MS animals is a rather unexpected result, if one take into account the much higher development of adipose tissue in MS pigs. However, this is consistent with the similar or lower daily fat and lipid deposition in MS comparatively to LW pigs (see section 2).

5) SOMATOTOTROPIC HORMONE SECRETION

Pig growth has been demonstrated to be highly sensitive to the action of porcine somatotropin (pST ; also known as porcine Growth Hormone or pGH).

In most models of slow growing-fat pigs so far studied, pGH and IGF-I levels are lower than in conventional animals (see BONNEAU, 1990 for review). However, in comparison to conventional pigs, pGH levels are about normal but IGF-1 concentrations are markedly lower in Yucatan Micro pigs, whereas both pGH and IGF-1 levels are normal or even higher than normal in Yucatan Mini or Hanford Mini pigs (LAUTERIC et al. 1988).

As far as we know, somatotropic hormone status of Meishan pigs has not yet been investigated. Data presented in the present section deal with age-related changes in plasma pGH and IGF-I levels and to pGH response to insulin challenge in MS vs LW pigs.

5-1) Age related changes in plasma pGH and IGF-I levels

Table 7. Age-related changes in plasma growth hormone (pGH) profile criteria and IGF-I levels in LW and MS pigs (LOUVEAU et al., 1990).

Age (d)	Breed	--------- Plasma pGH profile criteria ---------					IGF-I levels (U/ml)
		Mean levels (ng/ml)	Base-line levels (ng/ml)	Peak frequency (peaks/8hrs)	Peak duration (min)	Peak amplitude (ng/ml)	
10	LW	5.5	3.0	5.3	42	10.6	25.5
	MS	6.5	4.4	4.2	42	12.0	18.2
30	MS	7.9	6.3	2.9	54	12.8	16.7
45	LW	5.8	3.1	3.5	77	9.4	19.6
	MS	7.4	5.9	3.3	56	11.0	31.4
70	MS	3.3	2.4	3.0	61	7.0	121.0
140	LW	3.3	2.0	3.2	77	7.1	116.6
	MS	4.4	3.8	2.0	65	7.3	78.6
Significance of effects							
Age		***	***	**	***	***	***
Breed		*	***	NS	NS	**	NS
Age*Breed		NS	NS	NS	NS	NS	NS

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Plasma pGH profiles and IGF-I levels were determined in entire male LW pigs at 10, 45 and 140 days of age and in entire male MS pigs at 10, 30, 45, 70 and 140 days of age (Table 7). Six animals of each breed were studied at each age. Plasma pGH levels were measured on blood samples withdrawn every 20 minutes for 8 hours. Plasma IGF-I levels were determined on plasma pools constituted within animals over the 8 hr period of blood sampling.

In both LW and MS pigs, mean pGH levels declined with age. Peak frequency was higher and peak duration was lower in 10 day old pigs than in the other age groups. Peak amplitude and base-line levels decreased after 45 days of age. IGF-I levels increased with age in the two breeds. Age-related changes in pGH profile criteria and IGF-I levels were similar in the two breeds, as demonstrated by the non significant age*breed interactions. Mean pGH levels, base-line and peak amplitude were significantly higher in MS than in LW pigs while peak frequency and duration as well as IGF-I levels did not differ significantly between the two breeds.

5-2) pGH response to insulin challenge.

Provocative stimuli are often used to characterize growth hormone secretion in mammals. Plasma glucose and pGH response to insulin challenge was measured in six castrated male LW and six castrated male MS pigs aged 140 days. Each animal was challenged three times with 3 different insulin dosages (0.03, 0.10 and 0.30 UI/kg BW).

Table 8. Plasma glucose and pGH response to insulin challenge in LW and MS pigs (BONNEAU and BRAULT, 1990).

Breed	Insulin dosage (UI/kg)	----- Glucose ----- Minimum (g/l)	AAC[1]	-------- pGH-------- Maximum (ng/ml)	AUC[1]
LW	.03	.38	11	14.5	315
	.10	.18	33	27.9	917
	.30	.17	45	28.5	1070
MS	.03	.31	23	8.1	49
	.10	.18	36	9.5	182
	.30	.10	55	8.1	100
Significance of effects					
Dosage		***	***	**	***
Breed		NS	**	***	***
Dosage*Breed		NS	NS	*	**

[1] Area above the curve of plasma glucose (AAC ; $g*l^{-1}*min$) or under the curve of pGH (AUC ; $ng*ml^{-1}*min$) concentrations between 0 and 100 min after insulin injection.

Plasma glucose levels dropped sharply after insulin injection. Initial glucose fall was similar in LW and MS pigs and minimum glucose levels did not differ between the two breeds (table 8). However, glucose return to pre-insulin levels was slower in MS than in LW animals, so that AAC of glucose

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was larger in MS pigs. Plasma pGH levels increased sharply in LW animals. Plasma maximum pGH level and AUC of pGH concentration after insulin challenge were much lower in MS than in LW animals.

Thus, despite a larger glucose response, MS pigs exhibited a much lower response to insulin than LW animals. This result is consistent with the blunted pGH response to insulin in the obese Ossabaw pig (WANGNESS et al., 1980). However, spontaneous pGH secretion is lower in Ossabaw than in conventional pigs (WANGNESS et al., 1977, 1981 ; McCUSKER et al., 1985) whereas it is not impaired in MS animals (see section 5-1). These data suggest that, although spontaneous pGH secretion seems to be similar in MS and LW pigs, the regulation of pGH release may be different between the two breeds.

6) THE EFFECT OF PORCINE SOMATOTROPIN ON GROWTH AND PERFORMANCE

Administration of pST dramatically improves growth performance and carcass characteristics of swine (see BONNEAU, 1990 for review). A comparison of pST effects in obese MS and extremely lean Pietrain (PI) has been conducted to investigate the possible interaction between pST effects and endogenous potentialities of the animals for muscle growth.

Table 9. The effect of pST administration on growth performance, carcass characteristics and bone development of Meishan, Crossbred and Pietrain pigs. (Bidanel et al., 1990).

Breed	Meishan			Crossbred			Pietrain		
Treatment	CTRL	pST	Sign[1]	CTRL	pST	Sign[1]	CTRL	pST	Sign[1]
Average daily gain (kg/d)	.422	.603	***	.722	.852	***	.589	.771	***
Daily feed intake (kg/d)	2.57	2.31	NS	2.74	2.28	**	2.17	2.01	NS
Feed conver sion ratio	6.21	3.88	***	3.82	2.71	***	3.79	2.60	***
Back fat thickness (mm)	38.9	23.1	***	24.1	13.5	***	15.1	9.7	***
% muscle	34.4	45.8	***	53.8	59.8	***	60.8	62.7	*
% fat	42.7	30.6	***	22.3	15.5	***	15.0	12.6	*

Twenty four gilts of each of the three genotypes, MS, PI or crossbred (CR ; 1/2 PI, 3/8 LW, 1/8 MS) received either a daily injection of 6 mg pST or a placebo from 60 to 100 kg live weight.

Average daily gain was increased dramatically and similarly in the 3 genotypes (+.165 kg/d) by pST treatment. Feed conversion ratio was more reduced in MS (-2.3) than in the other two genotypes (-1.1). The increase in percentage muscle, and the related decrease in fat content of the carcass after pST treatment were higher in MS (muscle :+11.4 ; fat -12.1) than in CR

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(muscle :+6.0 ; fat -6.8) and higher in CR than in PI (muscle :+1.9 ; fat -2.4). The increase in muscle content and decrease in fat development of pST treated MS pigs were higher than in the results of VAN DER STEEN et al. (1989). However, the authors used twice weekly injection that are likely less efficient than daily injections.

The results of the present study demonstrate the existence of a genetic variability in the response of pigs to pST treatment. The improvement in performance and carcass characteristics is in inverse proportion of the potentialities of the animals for muscle growth. Genetic differences are still existent, however reduced after pST treatment.

CONCLUSION

MS pigs are mostly characterized by poor growth performance and high development of adipose tissue. Lower growth rate, comparatively to LW animals, is the result of lower feed intake and much smaller rates of muscle deposition and protein accretion, in connection with the lower number of muscle fibers at birth and the reduced postnatal development of type IIb fibers. Fat and lipid deposition rates are similar or even smaller in MS than in LW, in connection with similar or lower lipogenic enzyme activities. Spontaneous pGH and IGF-I secretions do not seem to be impaired in MS animals. However, the blunted pGH response to insulin challenge in MS animals suggest that the regulation of pGH secretion may differ between MS and LW pigs. The effect of pGH on target tissues does not seem to be impaired in MS animals since growth performance and carcass characteristics are very responsive to exogenous pST administration.

Thus, the poor performances of MS pigs seem to be mostly the result of too few muscle fibers at birth and impaired postnatal development of glycolytic fibers. The mechanisms responsible for these differences remain to be elucidated.

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