Phenotypic and genetic parameters of intramuscular fat in pigs

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Objective

Decrease of intramuscular fat has a strong influence on the sensory quality of meat, because fat contributes to the species specific flavour of meat. The objective of this work was the evaluation of the correlations between intramuscular fat and fattening and carcase traits and to look for the possibility to attain an optimal percentage of fat in muscle by selection.

Material and methods

A total of 1601 Swiss Large White pigs (SLW), 677 Swiss Landrace pigs (SL) and 102 Hampshire pigs (H) from nucleus breeding herds, which passed through the full sib testing program at the Swiss Pig Performance Testing Station in the year 1985 were included in this analysis. The animals were kept in groups of two females and two castrates under standardised conditions and ad libitum feeding. Management and feeding conditions are presented in the annual report 1985 of the testing station (Rebsamen et al., 1986).

Besides fattening traits (fattening period at the testing station: 25-103 kg), slaughtering traits were also recorded, in particular: the proportion of premium cuts (amount of loin %, ham %, shoulder %), the proportion of loin-, ham- and shoulder-fat, the leaf and the backfat thickness. The dissection of the carcase was performed 26 h after slaughter. Proportions are calculated as percentage from the cooled carcase. Meat quality estimation includes pH- and reflectance measurements (Unigalvo) 45 min. p.m. and/or 26 h p.m. Details are explained by Schwörer (1982). The amount of fat in the M. long. dorsi (10th rib) was evaluated with the fatextraction system Soxtec HT (Tecator).

The data were analysed by analysis of variance (Harvey, 1972) and corrected according to model 1:

$$Y_{ijm} = \mu + G_i + Q_j + e_{ijm} \qquad \text{(model 1)} \qquad (1)$$

with
Y_{ijm} = trait of the m-th animal
μ = least square mean
G_i = effect of the i-th sex (fixed)
Q_j = effect of the j-th 2-month-classes (fixed)
e_{ijm} = random error.

Additionally, the traits were corrected for hot carcase weight by including it as regression into model 1. Slaughtering traits were corrected for the slaughter-house by including slaughter-house as a fixed factor in model 1.

Heritability estimates and genetic correlations were estimated by paternal half-sib and full-sib correlations. Because of the low number of Hampshire animals, an evaluation of the genetic parameters in this breed was not carried out.

To estimate the genetic parameters, model 2 was used after correcting the data by model 1.

$$Y_{ijkl} = \mu + F_i + S_{ij} + D_{ijk} + e_{ijkl} \qquad \text{(model 2)} \qquad (2)$$

with
Y_{ijkl} = trait of the l-th animal
μ = least square mean
F_i = effect of the farm i (fixed)
S_{ij} = effect of the j-th boar within the farm i (random) (boars in natural service and AI)
D_{ijk} = effect of the k-th sow which was mated on the farm i to the boar j (random)
e_{ijkl} = random error.

Analysis of variance for model 2 is shown in table 1.

Table 1: Analysis of variance for model 2

Source	Degrees of freedom	Expected mean squares
Between farms	F - 1	$\sigma^2_e + k_4\sigma^2_D + k_5\sigma^2_S + k_6\sigma^2_F$
Between sires within farms	S - F	$\sigma^2_e + k_2\sigma^2_D + k_3\sigma^2_S$
Between dams within farms and sires	D - S	$\sigma^2_e + k_1\sigma^2_D$
Rest	N - D	σ^2_e

(3)

Heritability estimates are obtained from the following formulas:

$$h^2_S = \frac{4\,\sigma^2 S}{\sigma^2 P} \quad (4) \qquad h^2_{FS} = \frac{2\,(\sigma^2 S + \sigma^2 D)}{\sigma^2 P} \quad (5)$$

Symbols

F = farm
S = sire
D = dam
N = number of animals
FS = full-sib

Standard errors of heritabilities were calculated according to Graybill and Robertson (1957). Phenotypic and genetic correlations between observations x and y are obtained from the following formulas:

$$r_{P_{xy}} = \frac{\sigma_{P_{xy}}}{\sigma_{P_x} \cdot \sigma_{P_y}} \quad (6) \qquad r_{g_{xy}} = \frac{\sigma_{S_{xy}}}{\sigma_{S_x} \cdot \sigma_{S_y}} \quad (7)$$

Standard errors of phenotypic and genetic correlations were calculated according to Fisher (1956) and Robertson (1959). Farms and sires were selected especially. Only farms with at least 4 animals and sires with at least 7 descendants were accepted.

Earlier evaluations have shown that maternal effects are influencing daily gain. For that reason genetic parameters of fattening traits were evaluated by half-sib analysis. Full-sib analysis was used for all other traits.

Results

Fattening and slaughtering traits for the breeds are shown in table 2. Marked differences in the amount of intramuscular fat in the M. long. dorsi exist between breeds (SLW: 1.36 %, SL: 1.16 %, H: 1.94 %).

Table 2: Comparison of performances (mean, standard deviation) between Swiss Large White (SLW)-, Swiss Landrace (SL)- and Hampshire (H)-pigs

Traits	SLW (N=1601) $\bar{x}$	s_x	SL (N=677) $\bar{x}$	s_x	H (N=102) $\bar{x}$	s_x
Daily gain (birth-103 kg), g	638	45	619	43	599	40
Daily gain (25-103 kg), g	866	91	835	86	816	72
Premium cuts, %	54.16	2.94	53.47	2.91	52.86	2.56
Backfat, %	8.19	1.61	8.72	1.64	8.61	1.26
Hamfat, %	3.75	0.55	4.09	0.56	3.83	0.52
Shoulderfat, %	2.73	0.41	2.67	0.37	2.76	0.31
Leaf, %	2.04	0.46	2.32	0.46	2.38	0.41
Fat thickness, back, cm	2.0	0.5	2.1	0.5	2.1	0.4
pH_1	6.07	0.22	6.00	0.25	6.14	0.18
pH_{30}	5.46	0.09	5.47	0.08	5.45	0.06
Reflectance, Unigalvo	32.0	3.5	32.0	4.4	31.2	3.8
Obj. meat quality score	3.57	0.60	3.41	0.82	3.75	0.52
Intramuscular fat, %	1.36	0.66	1.16	0.59	1.94	0.85

In all three breeds an increase in premium cuts or a decrease in the amount of subcutaneous fat and leaf is followed by a decrease in the amount of fat in muscle (loin) (tables 3 and 4):

premium cuts / i.m. fat; r_p: -.18 to -.21; r_g: -.24 to -.28
fat quantity parameters / i.m. fat; r_p: .03 to .19; r_g: -.03 to .42

By improving daily gain, intramuscular fat in the loin increases also (tables 3 and 4):

daily gain / i.m. fat; r_p: -.13 to .13; r_g: .08 to .52.

Table 3: Phenotypic correlations (r_p) between intramuscular fat and fattening and slaughtering traits as well as meat quality, according to breeds

Traits	Intramuscular fat, %					
	SLW (N=1601)		SL (N=677)		H (N=102)	
	r_p		r_p		r_p	
Daily gain (birth-103 kg), g	.01	n.s.	.08	*	-.13	n.s.
Daily gain (25-103 kg), g	.04	*	.13	***	.03	n.s.
Premium cuts, %	-.21	***	-.18	***	-.18	*
Backfat, %	.15	***	.19	***	.08	n.s.
Hamfat, %	.13	***	03	n.s.	.06	n.s.
Shoulderfat, %	.15	***	.09	*	.17	*
Leaf, %	.17	***	.19	***	.07	n.s.
Fat thickness, back, cm	.10	***	.06	n.s.	.12	n.s.
pH_1	-.06	*	-.04	n.s.	.10	n.s.
pH_{30}	-.01	n.s.	-.07	n.s.	.12	n.s.
Reflectance, Unigalvo	.20	***	.09	*	.06	n.s.
Obj. meat quality score	-.14	***	-06	n.s.	.12	n.s.

n.s. = not significant
* = $P < 0.05$
** = $P < 0.01$
*** = $P < 0.001$

Table 4: Genetic correlations (r_g) between intramuscular fat and fattening and slaughtering traits as well as meat quality, according to breeds. Standard-errors (s_{r_g}) in parenthesis

Traits	Intramuscular fat, %			
	SLW (N=1601)		SL (N=677)	
	r_g	s_{r_g}	r_g	s_{r_g}
Daily gain (birth-103 kg), g	.08	(.19)	.52	(.21)
Daily gain (25-103 kg), g	.20	(.22)	.45	(.19)
Premium cuts, %	-.28	(.11)	-.24	(.17)
Backfat, %	.24	(.10)	.30	(.15)
Hamfat, %	.14	(.11)	.03	(.17)
Shoulderfat, %	.20	(.11)	.22	(.18)
Leaf, %	.27	(.10)	42	(.15)
Fat thickness, back, cm	.19	(.11)	.08	(.17)
pH_1	.15	(.17)	-.02	(.19)
pH_{30}	.45	(.25)	-.22	(.22)
Reflectance, Unigalvo	.19	(.17)	.09	(.19)
Obj. meat quality score	-.12	(.19)	.00	(.19)

Heritability estimates of intramuscular fat indicate the possibility to prevent a diminution of intramuscular fat by including it into selection (table 5: h^2 i.m. fat, SLW: .54, SL: .58). The cited values are in line with values estimated by Malmfors and Nilsson (1979), Scheper (1979) and Just et al. (1983).

Table 5: Heritabilities (h^2) and standard errors (s_{h^2}) for intramuscular fat, fattening and slaughtering traits as well as meat quality, according to breeds

Traits	SLW (N=1601)		SL (N=677)	
	h^2	s_{h^2}	h^2	s_{h^2}
Daily gain (birth-103 kg), g	.38	.09	.42	.14
Daily gain (25-103 kg), g	.23	.08	.62	.16
Premium cuts, %	.73	.06	.80	.09
Backfat, %	.73	.06	.76	.09
Hamfat, %	.71	.06	.73	.09
Shoulderfat, %	.54	.06	.47	.09
Leaf, %	.69	.06	.65	.09
Fat thickness, back, cm	.56	.06	.77	.09
pH_1	.17	.05	.45	.08
pH_{30}	.08	.04	.29	.08
Reflectance, Unigalvo	.16	.05	.43	.08
Obj. meat quality score	.12	.04	.44	.08
Intramuscular fat, %	.54	.06	.58	.09

Degrees of freedom:

SLW: 60 farms, 155 boars/farms, 210 sows/boar/farms
SL: 29 farms, 71 boars/farms, 80 sows/boar/farms

Conclusion

By selecting for a high percentage of premium cuts, the amount of intramuscular fat should be taken into consideration if a decrease of intramuscular fat has to be prevented.

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