GENETIC PARAMETERS FOR PIG MEAT QUALITY

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SUMMARY

Pig meat quality was studied in (halothane negative) Dutch Yorkshire lines. Various traits were measured in the abattoir and at the laboratory (a.o. pH, drip, cooking loss, colour, tenderness and intramuscular fat). Variance components and correlations were estimated at three levels: genotype, day of slaughter, and non-systematic environment. The genetic variance of waterbinding and colour traits appeared to be of the same magnitude as the variance due to day of slaughter (about 20%). Relationships between laboratory and abattoir traits showed good opportunities for genetic improvement, using relatively simple measurements like pH and reflectance. No unfavourable genetic correlations could be found between carcass lean % and waterbinding or colour traits. High heritabilities and a rather strong negative genetic relationship were found between carcass lean % and intramuscular fat %.

INTRODUCTION

Breeding organizations form the first part of the production chain in the pork industry. They need to provide the genetic base for quality meat, which pig producers and processors can then exploit using good management and handling procedures.

Apart from the effects of the halothane gene, knowledge about genetic effects on pork quality is limited. The same holds for environmental effects. Quantification of genetic parameters is needed to evaluate the possible role of breeding organizations, and to find optimal strategies for integrating selection for meat quality in present genetic improvement programmes. Since it can be assumed for todays breeding populations that the halothane gene is under control, either by gas testing (Eikelenboom and Minkema 1974) or by DNA-probing (Fuji et al. 1991), research should focus on the effects of other genes.

The aim of the present study is to quantify parameters of pig meat quality traits in halothane free populations. Data from 7 Dutch Yorkshire lines were used to estimate variances and covariances due to genotype and slaughter environment.

MATERIAL AND METHODS

Data

The experiment was set up in cooperation with 7 Dutch breeding organizations. From each organization a random sample of one of their sire lines was evaluated. These lines were claimed to be halothane free, based on phenotypic gas testing. All animals were of Dutch Yorkshire origin. The performance testing was done within each breeding organization's own test facilities, in general under ad lib feeding conditions. Each breeding organization also used their own slaughter facilities. Pigs were slaughtered in weekly batches.

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Comprehensive meat quality evaluations were done, on average, on 7 pigs per week. Some traits were also measured on about 10 additional animals. Transport and handling was standardized within breeding organization. At the abattoir leanness and different meat quality traits were measured at 45 minutes post mortem, determined at the M. longissimus dorsi between 3rd and 4th lumbar vertebrae, as:

- carcass lean percentage estimated with the Hennessy grading probe (Walstra 1988); Lean%
- PSE reflectance measurement by the Hennessy grading probe; HGP-PSE
- pH value; pH1.

The day after slaughter (about 20 hrs. post-mortem), the following measurements were taken:

- reflectance measurement by the Fibre Optic Probe (between 3rd and 4th lumbar vertebrae); FOP
- pH value (same position); pH2
- L* value (paleness) according to Cielab system with a tristimulus colour analyzer (Minolta CR 110) at the loin surface between 2nd and 3rd lumbar vertebrae after blooming for 30 min; Minolta L*.

For a more comprehensive evaluation of part of the populations, samples from the loin between the last and the 2nd lumbar vertebrae were transported to our institute. In the laboratory, the following measurements were performed after 24 hours post-mortem:

- pH value (between 3rd and 4th lumbar vertebrae); pH3
- measurement of waterholding capacity with the filter paper test (Kauffman et al. 1986); Filter paper
- L* value (paleness) according to Hunter Labscan spectro colorimeter LS-5000 after blooming for 30 min; Hunter L*
- measurement of water uptake during low speed centrifugation (Wierbicki et al. 1962); Swelling %
- drip loss, derived from the method of Honikel (1987); samples stored during 48 hours at 4 °C on an absorption pad and covered with a packaging film; Drip loss
- cooking loss, determined after Drip loss, by packing the samples in vacuumized polyethylene bags and heated during 60 min in a 75 °C waterbath (Boccard et al. 1981); Cooking loss
- tenderness measurement, using 10 cores from the heated samples (Boccard et al. 1981); average of maximum forces required to shear the cores with a Warner-Bratzler blade; Shearforce
- intramuscular fat determined in a loin sample by the Fosslet extraction method (Olsman 1978); Intram. fat.

Statistical analysis

The following mixed model was used for analyzing the data:

$$y = Xb + Ls + Zu + e$$

where y is a vector of observations; b is a vector of fixed effects; s is a vector of random effects of day of slaughter; u is a vector of random additive genetic effects; X is the incidence matrix for fixed effects; L is the incidence matrix for day of slaughter; and Z is the incidence matrix for additive genetic effects. Fixed effects in the model were breeding organization (7 levels) and sex (3 levels). Random slaughter day effects (257 levels) were nested within breeding organization. For the genetic effects, up to 3 generation relationships were used fitting an animal model. Univariate REML estimates of the parameters were derived using a derivative free algorithm (Meyer 1991). A variance of the log likelihood values of 0.001% was taken as convergence criterion. Approximate standard errors were calculated for the variance components (Meyer 1991).

Correlations were estimated, following the approach of Thompson and Hill (1990), using a canonical transformation and calculating covariances as half the difference between the variance of the sum of two traits and the summed variances of the individual traits (after scaling to equal phenotypic variances). In the first round, the original traits were analyzed. In the following rounds, the traits were transformed to canonical variates using priors derived from the previous round. The procedure was stopped when the maximum change in correlation between successive rounds was less than 0.05. Standard errors on the correlations could not be derived with the procedure, but they might be approximated using the formula given by Falconer (1989).

RESULTS AND DISCUSSION

Sources of variance

Table 1 shows that percentage of total variance explained by fixed effects (R^2) and accounted for by day of slaughter (s^2) were quite low for lean % and intramuscular fat. This indicates small differences between the breeding populations and between batches. The heritabilities of these two traits were quite high (0.52 and 0.41), in agreement with the literature.

R^2 values for pH, colour and waterbinding traits were around 0.20. These values can be explained by differences in preslaughter management, e.g. one of the breeding organizations always kept the pigs for one night at the abattoir. Components of variance due to genotype (h^2) and day of slaughter (s^2) appeared to be of the same order, around 0.20. Estimates of s^2 were higher than expected, because (within breeding organization) transport and (pre-)slaughtering conditions hardly varied between batches.

With a heritability of 0.20, both drip loss and colour would respond to selection in breeding populations. The optimal breeding objective for these traits is debatable (Lundstrm 1989). To reduce the incidence of PSE meat, selection should be for darker meat with lower drip loss. At the same time, care is needed not to raise the chance of DFD meat.

Table 1. Percentage of total variance explained (R^2) by fixed effects (breeding organization and sex), phenotypic standard deviation ($\__p$), relative part of phenotypic variance due to genotype (h^2) and day of slaughter (s^2)

Trait	R^2	$\__p$	h^2 (s.e.)	s^2 (s.e.)	n[1)]
45 min pm					
Lean %	0.11	2.35	0.52 (0.05)	0.03 (0.01)	4055
HGP-PSE	0.11	6.52	0.18 (0.03)	0.27 (0.02)	4055
pH1	0.07	0.319	0.15 (0.03)	0.17 (0.02)	4055
20 pm					
FOP	0.41	10.2	0.15 (0.03)	0.13 (0.02)	4055
pH2	0.29	0.217	0.21 (0.03)	0.21 (0.02)	4055
Minolta L*	0.15	3.51	0.21 (0.05)	0.17 (0.02)	1881
> 24 hr pm					
pH3	0.19	0.208	0.15 (0.05)	0.22 (0.03)	1881
Filter paper (mg)	0.07	22.5	0.20 (0.05)	0.21 (0.02)	1881
Hunter L*	0.22	3.02	0.27 (0.06)	0.11 (0.02)	1837
Swelling %	0.25	24.8	0.20 (0.05)	0.14 (0.02)	1881
Drip loss (%)	0.20	1.84	0.20 (0.06)	0.14 (0.02)	1837
Cooking loss (%)	0.13	2.75	0.11 (0.05)	0.21 (0.03)	1837
Shearforce (daN)	0.12	0.559	0.20 (0.05)	0.17 (0.02)	1881
Intramusc.fat (%)	0.05	0.505	0.41 (0.07)	0.08 (0.02)	1837

1) n: number of records

Correlations

Table 2 shows correlations between laboratory and abattoir traits. Genetic correlations (r_G) appear to be stronger than correlations at slaughter day (r_S) or error level (r_E). Lower r_P's compared to r_G's were also found in other studies (a.o. Cameron 1990; Hovenier et al. 1992). They might be explained by uncorrelated random measurement errors. The high r_G values for Hunter L* and waterbinding traits with pH and FOP indicate good opportunities for genetic selection for meat quality based on cheap non-destructive measurements at the abattoir.

The r_G's of lean % with waterbinding and colour appear to be close to zero in the present study. This does not agree with many previous studies, reporting unfavourable genetic relationships. The differences in the results can probably be explained by the halothane sensitivity status of the studied populations (Sellier 1988).

The negative correlation between lean % and intramuscular fat % (-0.37) is in agreement with the literature. Since intramuscular fat % is at the moment probably below its optimum, the negative correlation with lean % can be considered as unfavourable.

CONCLUSIONS

Waterbinding and colour

- The genetic variance of colour and waterbinding traits is of the same magnitude as the variance between batches (about 20%).
- Colour and waterbinding showed no unfavourable correlations with carcass lean %.
- Selection for meat quality can be based on relatively inexpensive measurements taken in abattoir.

Intramuscular fat

- The heritability of intramuscular fat % is high (40%).
- Intramuscular fat % is unfavourably related with carcass lean %.

Table 2. Correlations between laboratory and abattoir measurements due to genetic effects (r_G), day of slaughter (r_S), non-systematic environment (r_E), and the combination of these 3 factors (r_P)

		Abattoir measurements				
Laboratory		HGP-PSE 45 min	pH1 45 min	FOP 20 hr	pH2 20 hr	Lean %
Drip loss	r_G	0.14	-0.56	0.55	-0.69	-0.10
	r_S	0.03	-0.22	0.47	-0.48	-0.22
	r_E	0.17	-0.46	0.44	-0.45	0.17
	r_P	0.14	-0.44	0.46	-0.49	0.05
Cooking loss	r_G	0.26	-0.24	0.66	-0.82	-0.06
	r_S	-0.14	0.14	0.15	-0.39	-0.08
	r_E	-0.06	-0.12	0.13	-0.40	0.21
	r_P	-0.03	-0.09	0.19	-0.46	0.10
Hunter L*	r_G	0.14	-0.27	0.62	-0.69	-0.09
	r_S	0.02	-0.04	0.23	-0.56	-0.23
	r_E	0.19	-0.21	0.42	-0.48	0.04
	r_P	0.15	-0.20	0.43	-0.53	-0.03
Intram. fat	r_G	0.32	-0.12	0.32	-0.23	-0.37
	r_S	0.03	-0.22	0.03	0.10	-0.08
	r_E	0.11	0.05	0.07	0.16	-0.12
	r_P	0.15	-0.04	0.12	0.04	-0.23

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