POTENTIAL TO IMPROVE PORK TEXTURE BY MEANS OF BREEDING

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Abstract – The aim of this study was to evaluate the possibility to breed for improved pork texture and to investigate the current relationship between pork texture in terms of Warner Bratzler shear force (WBSF) and other quality and performance traits. WBSF and cooking loss was measured in a total of 500 Swiss Large White (LW), LW-sire line (LWS), and LWS F2 crossbred animals.

Pedigree information of 3633 additional animals was used to estimate heritability as well as phenotypic and genetic correlations for average daily gain (ADG), proportion of noble parts in the carcass (NP), intramuscular fat content, pH 45 min. and 24 h. post mortem, drip loss, WBSF and cooking loss. Samples from 73 selected animals were also tested for the genetic markers CAST 249 and 638 and PRKAG.

The heritability of WBSF was high (0.39) and the genetic correlation with ADG favourable (-0.44) while it was unfavourable with NP (0.38). None of the genetic markers were sufficiently informative regarding WBSF or other quality traits.

Key Words – tenderness, heritability, genetic markers

I. INTRODUCTION

Within all the attributes that define meat quality, tenderness occupies a central place and is determinant for meat acceptance [1,2]. The aim of the present study therefore was to estimate the genetic parameters of a pork texture trait associated with tenderness as a basic requirement for evaluating the possibility to breed for improved meat texture in the Swiss Large White pig population. Beside the classical approach with phenotype based selection and multi-trait breeding index also marker assisted selection was to be considered, using described markers for water holding capacity and meat texture [3].

II. MATERIALS AND METHODS

Data and samples of purebred Swiss Large White (LW, n=59), purebred Swiss Large White sire line (LWS, n=262) and commercial endproducts (LWS x (Swiss Landrace x LW), n=179) were obtained from the SUISAG performance testing station at Sempach, Switzerland. Of these animals, 251 were gilts and 249 barrows. Average daily gain (ADG), feed conversion ratio (FCR), carcass weight (CW), backfat thickness (BF), proportion of noble parts (trimmed shoulder, loin, and hind leg, NP) were recorded according to the performance testing routine. At 45 minutes and 24 hours post mortem pHwas measured (pH45, pH24) in the *M. longissimus dorsi* (LD) at the 11th rib. At the same position a slice of the LD was taken to measure the intramuscular fat content (IMF) using an Infra-Alyzer 450 (Bran+Luebbe, Norderstedt, Germany, calibrated with results from trichlorethan extraction using a Soxtec System HT6, Tecator, Höganäs, Sweden). Another 2.5 cm slice was taken for drip loss 48 h (DL), cooking loss (CL) and texture analysis (Warner-Bratzler shear force, WBSF). After DL analysis, the slices were vacuum packaged and kept frozen until used for CL and WBSF analysis. The samples were thawed (2 hours in water bath at 20°C) and cooked (for 45 minutes in a water bath at 72°C). After cooling (10 minutes under running tap water) meat samples were taken out of the bags, dried and weighed for cooking loss (CL) calculation. WBSF was measured on 6 cores per slice sheared perpendicular to the direction of the muscle fibres using a TA.HD*plus* Texture Analyzer (Stable Micro Systems Ltd, Surrey, UK).

Analysis of variance was applied (R 2.12.1) to evaluate the effects of breed, sex, genetic markers and the interaction between breed and sex on the main traits. The general linear model also included carcass weight as a covariate, when appropriate. Multiple comparisons were carried out using the Tukey test.

The same data set described above was expanded by including a pedigree containing 3633 additional animals. Pedigree information was obtained from the herdbook computing center (SUISAG) in Sempach, Switzerland.The mixed linear model to estimate variance components (software VCE [4]) contained breed, sex, slaughter day, animal, and carcass weight as covariate. The multivariate analysis included the traits ADG, NP, IMF, pH45 and 24, DL, CL, and WBSF (table 2).

ADG translates into younger animals at slaughter and implicitly more tender meat.

The positive correlation between NP and WBSF reinforces the conflicting relationship between carcass leanness and meat quality.

Table 1 Means values of traits by breed and sex

	breed[1]				sex		
n	LW 59	LWS 262	LWSx 179	p	gilts 251	barrow 249	p
ADG (g/day)	626^{ab}	667^{a}	646^{b}	<0.0001	637	656	<0.0001
CW (kg)	82.1^{b}	83.7^{a}	82.6^{b}	<0.0001	82.9	82.7	1.0000
BF (cm)	3.0^{a}	2.5^{c}	2.6^{b}	<0.0001	2.5	3.0	<0.0001
NP (%)	56.6^{c}	59.2^{a}	58.2^{b}	<0.0001	59.1	56.9	<0.0001
IMF (%)	1.67^{ab}	1.80^{a}	1.68^{b}	0.0060	1.54	1.89	<0.0001
pH45	6.25^{b}	6.29^{a}	6.29^{ab}	0.0460	6.27	6.28	0.5170
pH24	5.48^{b}	5.46^{ab}	5.46^{b}	0.0063	5.45	5.48	<0.0001
DL (%)	1.41	1.62	1.74	0.0744	1.73	1.45	0.0011
CL (%)	30.1^{b}	30.7^{a}	30.1^{b}	0.0006	30.6	30.0	<0.0001
WBSF (N)	39.8^{ab}	39.6^{a}	38.1^{b}	0.0424	41.3	37.0	<0.0001

[1]means in the breed comparison lacking a common superscript differ significantly

From animals, showing very high or very low values of WBSF, IMF and cooking loss, respectively, ear tissue samples were send to Dr. van Haeringen Laboratorium b.v., Netherlands, for genetic marker analysis. The markers tested were CAST249, CAST638 and PRKAG3.

III. RESULTS AND DISCUSSION

The purebred sire line (LWS) showed the highest daily gain, lowest BF, and highest NP, while the purebred LW, a typical maternal line and therefore focused more on reproductive traits, were lowest in ADG and NP, and highest in BF (Table 1).

In terms of meat quality, differences between the breeds were small. All Swiss Large White and Swiss Landrace pigs are genetically homozygous stress resistant, which is reflected by the average pH45 clearly above 6.2.

The barrows, as expected, showed lower fattening performance, but better meat quality than the gilts.

The heritability indices (Table 2) were in the range of the results obtained by others for the respective traits [3]. WBSF showed a rather high heritability and therefore meets this basic requirement for the improvement by means of breeding.

ADG was negatively, thus favourably, correlated with WBSF. This might be expected as high

Table 2 Heritability (diagonal, bold), genetic (above) and phenotypic (below) correlations

	ADG	NP	IMF	pH45	pH24	DL	WBSF	CL
ADG	**0.18**	-0.09	-0.06	-0.02	-0.05	-0.16	-0.44	-0.11
NP	-0.26	**0.53**	-0.38	0.15	-0.34	0.23	0.34	0.38
IMF	0.06	-0.39	**0.62**	-0.02	0.19	-0.21	-0.23	0.39
pH45	-0.03	0.01	-0.02	**0.31**	-0.24	-0.57	0.20	0.08
pH24	0.05	-0.15	0.07	0.00	**0.18**	-0.52	-0.19	-0.25
DL	0.00	0.11	-0.12	-0.41	-0.11	**0.49**	-0.14	-0.10
WBSF	-0.21	0.29	-0.28	0.20	0.00	-0.09	**0.39**	0.37
CL	-0.03	0.17	0.09	0.08	-0.01	-0.07	0.26	**0.29**

Our results also showed that IMF was favourably related to texture as it was negatively correlated with WBSF. Similar results were found in other studies [1,5,6]. It was also shown [5,6] that consumers found pork with higher IMF more tender. However, the relation between WBSF and IMF is complex and matter of on-going discussion. On the one hand the optimum level of IMF for eating quality and consumer acceptance of pork is said to range from 2.5 to 3 % (also depending on the analytical method applied) [7]. In this view, lower values influence meat quality negatively, whereas a higher content do not further improve quality and may have a negative impact on consumer acceptance and purchase decision at the point of sale [7]. In our study only a small part of the variation in WBSF could be attributed to the IMF and the relationship was not linear (Figure 1). The graph shows that very high WBSF only occurred in samples with IMF below 2 % while high IMF seemed to assure low WBSF. So far the results gave support to the hypothesis of a negative impact of low levels of IMF on texture and explain observations which relate meat toughness to low IMF. On the other side, numerous samples with low IMF showed nevertheless low WBSF. All together this leads to the conclusion that the correlation is not based on a cause and effect relationship.

Rincker et al. [8] evaluated the impact of IMF on pork eating quality, as there was concern that continuous effort for producing lean carcasses and reduce backfat would have a negative impact on pork quality. They concluded that there was little influence of the amount of intramuscular fat on pork quality attributes and, therefore, increasing IMF would not necessarily result in a better eating quality.

pH is typically used as an indicator of pork quality with high final pH being favourable for meat tenderness. This is supported by studies that found a positive correlation between sensory tenderness [5,6] and final pH and/or a negative correlation between final pH and instrumental texture of the pork [5,6,9]. In contrast we found no phenotypic correlation between pH24 and WBSF, which is in accordance with Dilger et al. [1]. This could partly be explained by the small variation in pH24 (st dev. 0.06) or by genetic factors as it was suggested that the relation between ultimate pH and WBSF depends on the breed [10]. However, negative genetic correlation supported the idea of a favourable effect of higher final pH on tenderness (Table 2).

pH45 was positively correlated to WBSF, indicating that a lower pH at this time is associated with more tender meat. This, however, has to be seen in the context of the genetically stress resistant animals in this study.

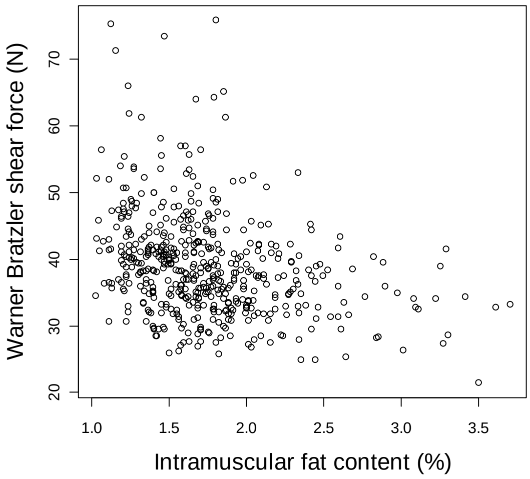

Figure 1 Relation between WBSF and IMF

Another important trait, from an economical as well as technological point of view, is the water holding capacity of the meat. DL showed a high heritability and is one of the traits commonly used in breeding for pork quality. The phenotypic correlation between WBSF and DL was close to zero in our study, which is consistent with other studies [1, 5]. However, the genetic correlation was negative, which means that breeding for low DL would put slightly unfavourable pressure on WBSF. CL on the other hand was positively correlated with WBSF. This leads to the hypothesis that early water loss from the meat is hardly related to the cooked meat texture while a higher loss of water during cooking results in tougher meat, probably as a consequence of increased compactness and heat induced protein aggregation [11].

The marker analyses revealed no significant differences between genotypes for any of the investigated quality traits. However, the genotype homozygous for Ser at CAST638 showed low DL, CL, and WBSF (Table 3). As this genotype is rather rare in the investigated population, extended analyses would be needed to clarify if this effect would become significant once the information of a bigger number of animals would be available. It also remains to be clarified, why the most favourable CAST638 genotype in this study does not match the haplotype described as favourable in the study which first identified these markers [12].

Table 3 Drip loss, cooking loss and Warner Bratzler shear forcer of the different PRKAG and CAST genotypes

	PRKAG3				CAST249				CAST638			
	II	IV	VV	p	AA	AL	LL	p	AA	SA	SS	p
n	10	30	42		6	26	42		42	26	5	
DL [%]	1.74	2.04	1.78	0.572	1.40	1.85	1.94	0.880	1.81	2.04	1.46	0.890
CL [%]	30.1	29.8	29.2	0.590	28.5	30.0	29.4	0.472	29.7	29.7	27.5	0.277
WBSF	43.0	37.5	35.3	0.859	32.3	38.6	37.2	0.689	37.7	38.0	29.7	0.540

IV. CONCLUSION

For the population studied, we can conclude that heritability and genetic correlations of WBSF would allow for improving pork texture following a classical multi-trait breeding index approach. Additional phenotyping for WBSF would however be laborious and expensive. Due to the favourable genetic correlations with ADG and other important quality traits, which currently are included in the breeding index, it is concluded that the current breeding practice has no negative impact on pork texture. Considering WBSF is therefore not urgently required.

The investigated, available genetic markers did not prove to be reliable enough. Further analyses would be necessary to clarify their use within the population studied. A marker assisted selection for improved pork tenderness therefore does not seem feasible at the moment.

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