Genotype-environment interactions for meat quality traits in different pig breeds kept under conventional and organic production systems

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Introduction

The suitability of modern or old pig genotypes for organic pork production is as widely as contrarily discussed in the organic pig fattening scene. The demand for special breeding programs for organic pig meat production is based on the assumption that genotype-environment interactions exist. It is often argued that under organic production systems old local breeds would perform better than modern hybrids selected under conventional systems. For milk production traits the first results clearly show that the genetic correlations between the same traits measured under conventional and organic conditions are for the economic important traits are all above 0.8 which is a sign of no genotype-environment-interaction Nauta *et al.* 2006, Simianer *et al.* 2007). For pigs this question is not finally answered yet. The breeding goals for organic pig meat production are very similar to those under conventional production systems, including reproductive performance of sows, daily weight gain, feed conversion ratio and meat percentage in the carcass as major economically important traits. Meat quality requirements are also the focus of both organic and conventional pig production systems although in both systems the meat quality is not included in the payment system for slaughter pigs. It was the aim of this study to verify possible genotype–environment interactions for meat quality traits in pigs.

Material and methods

Experimental design. In pigs there are only very few boars used through artificial insemination under conventional and organic production systems. So the approach to analyse genotype-environment-interaction through the genetic correlation between traits under both environments in pigs is hardly possible. To estimate a possible genotype-environment interactions a station test with 7 different pig breeds kept under conventional and under organic feeding and housing conditions was performed on two performance testing stations (Neu-Ulrichstein and Rohrsen) over 2.5 years with 6 replications. Environment was split into (i) conventional, characterised by housing and feeding conditions of German performance testing station standard as a reflection of modern intensive fattening systems, and (ii) organic, characterised by housing and feeding conditions in accordance to the EC Regulation 1804/99 (for more details see Brandt et al. 2009).

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The following 7 genotypes were tested: Angler Sattelschwein – AS (indigenous rare saddleback breed of North Germany), Schwaebisch-Haellisches Schwein – SH (indigenous saddleback breed of South Germany), Piétrain * AS – Pi*AS (crossbreed of AS with the commercial Piétrain sire line), Pi*SH (crossbred of SH with the commercial Piétrain sire line), Pi * Deutsches Edelschwein – Pi*DE (commercial cross with German Large White), Duroc * Deutsche Landrasse – Du*DL (commercial cross of Duroc with German Landrace) and Bundeshybridzuchtprogramm – BHZP (final product of a commercial breeding programme).Within all genotypes and both environments the number of females and castrates was almost balanced. No information was available about the pedigree of the animals, but the animals are from different multiplier farms, so we can assume a representative sample of the breeds. More details about the design of the experiment can be found by Brandt *et al*. (2009).

As meat quality traits the pH after 45 minutes (ph1k) in the cutlet, the pH after 24 hours in the ham (pH24s) and the cutlet (pH24k), the electrical conductivity after 1 and 24 hours (EC1 and EC24) in the cutlet and meat colour in the cutlet (Opto) were measured. For all animals tested in Rohrsen also the intramuscular fat (IMF), the protein and water content in the cutlet were analysed.

Statistical analyses. All meat quality traits showed a normal distribution and equal residual variances within all groups. Due to limited capacities within the testing stations the BHZP breed was tested on both stations and within each replication and all data were calculated as deviation from the BHZP group within station and replication. As a consequence only the fixed effects genotype, environment and sex were included in the model and the interaction between genotype and environment. Other significant interactions are shown in the results.

Results and discussion

The significance of fixed effects and interactions on the meat quality traits are shown in table 1. For meat quality traits shown here the genotype-environment-interaction is only highly significant for the intramuscular fat, the protein and water content in the cutlet and the pH value in the ham after 24 hours, whereas this interaction was highly significant for all growth and carcass traits as shown by Brandt *et al*. (2009).

Table 1: Significance of fixed effects and their interactions on meat quality traits

Traits	Genotype	Environment	Sex	Genotype*Sex	Genotype*Environment
pH1k	***	n.s.	***	n.s.	n.s.
pHh24k	**	*	n.s.	n.s.	n.s.
pH24s	***	n.s.	**	n.s.	***
EC1	***	n.s.	**	n.s.	n.s.
EC24	***	**	n.s.	n.s.	n.s.
Opto	*	**	n.s.	**	*
IMF	***	***	***	**	***
Protein	***	***	n.s.	n.s.	***
Water	***	***	***	***	**

*****: p < 0.001; **: p < 0.01; *: p < 0.05; n.s.: not significant**

The least square means for all animals tested on both stations for the meat quality traits for environments within genotype are shown in table 2. All genotypes show a good meat quality concerning meat quality problems with PSE (pale, soft and exudative) or DFD (dark, firm and dry) problem. The average pH1 value in the cutlet is above 6.2 for all genotypes. There are only very small significant differences found between environments within genotype, except for intramuscular fat, protein and water content in the cutlet. The missing environmental influence is according to the annotations of Fischer (2001). In figure 1 the least square means for intramuscular fat and protein content are shown as well as the difference between conventional and organic production system within genotype. From the figure it is obvious that the significant interaction between genotype and environment for intramuscular fat is caused mainly by the AS genotype showing a very high difference between environments as crossbred with Pi and the lowest difference between environments as purebred. In general all genotypes show a significantly higher intramuscular fat under organic conditions which is caused by the unbalanced supply of essential amino acids in the organic diet. This effect on intramuscular fat has been reported by other studies (Witte *et al*. 2000, D'Souza & Mullan 2002, Millet *et al*. 2004, Katsumata *et al*. 2005). With the increased intramuscular fat under organic conditions a reduction in protein content in the cutlet is observed. Here the highly significant interaction is also caused by the AS genotype, again showing the smallest difference between environments as purebred and the highest as crossbred with PI. Only the AS genotype as purebred or as crossbred with Pi shows differences in ranking between genotypes within environments for fat and protein content in the cutlet. The higher intramuscular fat with an average for all breeds above 2.5 % under organic conditions could result in a better sensory meat quality as shown in studies of Bejerholm & Barton-Gade (1986), Blanchard *et al.* (1999) and Wood *et al.* (2004).

Table 2: LSQ-means ± standard error and number of animals (n) for meat quality traits for conventional and organic production system within genotype

Genotype	Environment	n	pH24s	Opto	Water (%)
BHZP	conventional	86	5.54 ± 0.04	64 ± 0.8	74,82 ± 0,09
	organic	57	5.37 ± 0.04	62 ± 1.0	74,91 ± 0,12
AS	conventional	54	5.45 ± 0.05	64 ± 1.0	74,02 ± 0,09
	organic	28	5.65 ± 0.06	61 ± 1.4	73,91 ± 0,12
SH	conventional	25	5.52 ± 0.08	63 ± 1.7	- -
	organic	26	5.55 ± 0.08	65 ± 1.7	- -
PixAS	conventional	59	5.43 ± 0.04	62 ± 0.9	74,35 ± 0,09
	organic	33	5.38 ± 0.06	59 ± 1.3	73,67 ± 0,11
PixSH	conventional	26	5.51 ± 0.07	64 ± 1.4	- -
	organic	28	5.47 ± 0.06	65 ± 1.4	- -
PixDE	conventional	64	5.75 ± 0.04	66 ± 0.9	74,90 ± 0,08
	organic	41	5.51 ± 0.05	60 ± 1.1	74,79 ± 0,11
DuxDL	conventional	62	5.54 ± 0.04	66 ± 0.9	74,51 ± 0,09
	organic	42	5.54 ± 0.05	62 ± 1.1	74,09 ± 0,10

- - no data available (compare material & methods)

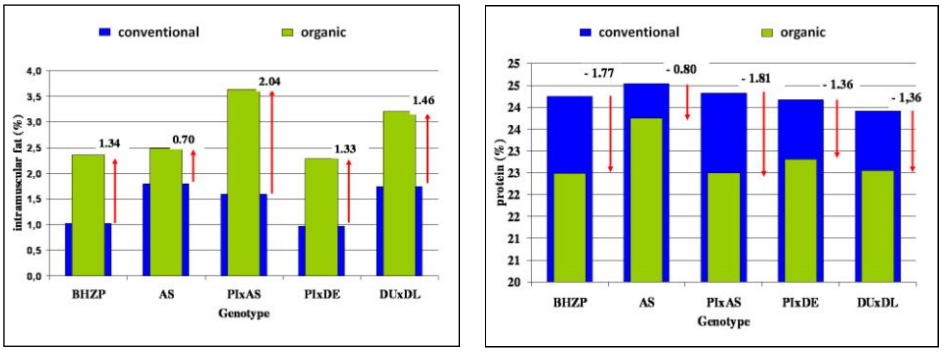

Figure 1: Least square means for environments within genotype and differences between environments within genotype for intramuscular fat and protein content

Conclusion

Genetically controlled physical pork quality traits like pH- and EC-values are unaffected by both housing and feeding systems and no genotype-environment interaction could be found. In contrast, chemical meat characteristics like meat fat and protein content are strongly influenced by genotype and feeding and a highly significant genotype-environment interaction. The differences between environments are caused by the differences in energy and amino acid supply between the conventional and the organic diets. Concerning intramuscular fat and protein content in the cutlet the genotypes, except the AS and PI*AS, show a very similar ranking in both environments, although the genotype-environment-interaction is highly significant. The significance is mainly caused by varying differences between environments within genotypes. Because of the higher intramuscular fat content in the cutlet for all genotypes under organic conditions the sensory meat quality for these animals could be better than for those under conventional conditions.

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