EFFECT OF GENETICS ON MEAT QUALITY AND SENSORY PROPERTIES OF PORK

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Background

The swine industry has achieved tremendous progress in genetic gains related to growth and feed efficiency as well as carcass fat reduction. As a consequence of these improvements there has been an increasing perception that the eating quality of pork has deteriorated over time. Some of these concerns are related to the reduction in fat content of muscle, i.e. intra-muscular fat, other concerns are related to the post-mortem biochemistry of pork, particularly the rate and extent of pH decline and the extent of myofibrillar proteolysis.

Objectives

Traits related to meat quality were investigated as part of a larger study, where overall carcass composition was studied in different PIC lines. Physico-chemical traits were compared between the different lines and related to sensory evaluations as well as correlated with each other. The literature provides us with many reports on the relationships between these predictive measurements and organoleptic parameters. However, this data set is quite unique in that it combines 10 different PIC lines of various phenotypic ranges.

Materials and methods

Animals came from the PIC genetic nucleus in Kipling Saskatchewan, Canada and was comprised of 30 market weight gilts from each of 10 lines for a total of 300 animals. The lines included the following basic genotypes: Landrace (Land), Large White (LW), Duroc (Dur), White Duroc (WDur), Berkshire (Berk), Hampshire (Hamp), Synthetic line (Syn), Crossbred Berkshire x Hampshire (BH), Pietrain hal negative (Piet-), Pietrain hal positive (Piet+).

Carcass Traits. Fat thickness (mm) and lean tissue depth (mm) were measured with a Hennessey Grading Probe at the $3^{rd}/4^{th}$ last ribs, 70 mm from the carcass mid-line approximately 40 minutes after harvest. Dissectible lean was determined as the weight of dissectible lean in the picnic, butt, loin, ham primal cuts plus the weight of the skinned trimmed belly and ribs as a percentage of cold side weight.

Muscle Quality Traits. The pH at 45 minutes (pH-45min) and 48 hours (pH-48h) post-slaughter, CIE L*, intramuscular fat (IMF), drip loss and shear value of the LT (*longissimus thoracis*) muscle were measured as described by Murray et al. (2001).

Sensory Traits. Perceived juiciness, flavor intensity, overall tenderness and overall palatability were assessed using a trained taste panel as described by Jeremiah et al. (1995).

Biochemical Measurements. LT muscle fiber types were determined by the combined SDH and myosin-ATPase method as described by Aalhus et al (1997). Samples, removed from LT muscles at 24 h post-harvest, were used to determine glycogen, glucose and lactate using a YSI Glucose-Lactate Analyzer and glucose-6-phosphate (Lang and Michal 1974). Glycolytic potential (GP) was calculated as (2*[glycogen + glucose + glucose-6-phosphate] + lactate) and is presented as μmoles lactate-equivalents per gram of muscle.

Statistical Analyses. Data were analyzed using the GLM procedure of SAS (2001) with statistical model slaughter day and line as classification variables. Least square means were compared by t-test. Correlation analyses made use of the CORR procedure (SAS 2001).

Results and discussion

Least squares means for meat and carcass traits are presented in Table 1. For most of the traits, Berk and Piet are at the two extremes. A number of line comparisons are highlighted below.

Carcass Traits. Based on both dissectible lean and backfat thickness, Berk carcasses are the fattest and Piet carcasses are the leanest. The genotypes used as sire lines, arranged in order of dissectible lean, are Dur, Hamp and Syn, with the Syn yielding significantly more dissectible lean than the Dur and having a much greater muscle depth than all lines except the Pietrain lines.

LT Quality Traits. Muscle traits differ significantly among genotypes, particularly for the Piet+, a halothane carrier animal that differentiates itself from the other genotypes for all of the muscle traits. Indeed this genotype shows the lowest pH-45min and pH-48h, the highest L* value, the greatest drip loss, lowest IMF and highest shear value. This is typical of what is expected for animals homozygous for the hal gene (Murray and Jones 1994). The Berk and the BH are at the other end of the spectrum for all of the traits. Interestingly the Dur shows intermediate pH values but has IMF levels as high as the Berk and the BH. It is also similar to the Berk in terms of shear value. This differs somewhat from the findings of Suzuki et al (2003) that Berkshire pigs had less IMF and lower drip than the Duroc pigs. Shear values are significantly higher for the Piet+, while the BH is the lowest, although not significantly different from the Berk or Hamp.

LT Sensory Traits. Sensory evaluation results indicate that the Piet has the lowest juiciness and palatability scores. Of interest is the fact that the Berk, BH and Duroc display sensory scores that are quite similar. The Hamp closely follows the Duroc. Similar studies (Brewer et al, 2002) support these observations.

LT Biochemical Measurements: Genotypes differ in their biochemical properties. The extremes in these measurements are depicted by the Piet+ and the Hamp, the latter having a lower proportion of red fiber and higher proportion of white fibers than the Piet+, the Berk being closer to the Piet+ for these traits. Klont et al. (1998) provides a good review of fiber type implications on meat quality. Residual glycogen is included to show that at 24 hours post-mortem metabolizable glycogen is present in all genotypes. GP is lowest for the Berk and highest for the Piet- which is closely followed by the Dur.

Correlation coefficients (Table 2) do not demonstrate a very high degree of association between the carcass, muscle quality, biochemical and sensory traits. The drip loss followed by pH-45min and IMF values seem to be the most related to juiciness, overall tenderness and overall palatability, although they explain at best approximately only 22% of the variation for a given trait (i.e. r=0.47 for pH-45min vs juiciness). Van Laack et al. (2001) found r values between IMF and shear value of –0.21 after 7 days of aging. Muscle quality traits are interrelated. The pH-48h is related to L* (r=-0.39) and drip (r=-0.33), as found by Huff-Lonergan et al. (2002). The pH-45min also show strong relationships with L* (r=-0.52) and drip loss (r=-0.68). The correlation between pH-48h and GP is quite high (r=-0.63) compared to the value of 0.39 reported by Huff-Lonergan et al. (2002).

Conclusions

Results from this study position the Duroc sire as potentially able to deliver fresh meat quality equivalent to the Berk, particularly with respect to marbling or intramuscular fat, in a carcass that has higher dissectible lean content. If IMF is not an issue the Syn genotype has the potential to deliver high meat quality at dissectible lean contents close to the Piet genotypes. Comparison of the ten PIC genetic lines of swine clearly demonstrates great diversity in carcass leanness, and muscle physical, sensory and biochemical traits. Appropriate combinations of these lines, along with a suitable nutritional regime, should produce the types of market pigs required to satisfy the diversity in current markets.

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Table 1. Carcass, muscle, sensory and biochemical traits.

LINE ^{z}	Lean (%)	Backfat	Lean Depth	pH-45min	pH-48h	L*	Drip	IMF	Shear
LW	59.6^{de}	14.1^{c}	51.2^{fg}	6.37^{bc}	5.55^{cd}	50.1^{e}	2.50^{c}	1.24^{d}	5.48^{b}
Land	59.5^{e}	13.9^{c}	53.2^{ef}	6.40^{abc}	5.57^{bcd}	50.4^{de}	2.49^{c}	1.36^{cd}	5.45^{b}
Dur	60.0^{cde}	15.1^{c}	54.0^{de}	6.34^{c}	5.55^{cd}	52.0^{c}	2.28^{cd}	2.57^{a}	5.15^{bcd}
WDur	61.4^{bcd}	14.7^{c}	54.0^{de}	6.36^{c}	5.58^{bc}	50.3^{e}	2.30^{cd}	2.35^{a}	5.42^{bc}
Hamp	61.6^{bc}	14.3^{c}	56.0^{d}	6.40^{abc}	5.56^{cd}	51.4^{cde}	2.33^{cd}	1.79^{b}	5.20^{bcd}
Berk	52.0^{g}	25.6^{a}	49.7^{g}	6.49^{a}	5.67^{a}	51.2^{cde}	1.84^{d}	2.68^{a}	5.12^{bcd}
BH	56.8^{f}	19.6^{b}	52.5^{ef}	6.47^{ab}	5.61^{b}	51.9^{cd}	2.07^{cd}	2.70^{a}	4.89^{d}
Piet-	62.9^{b}	14.2^{c}	66.5^{b}	6.23^{d}	5.53^{d}	53.6^{b}	3.32^{b}	1.66^{bc}	5.01^{cd}
Piet+	67.0^{a}	10.6^{d}	72.9^{a}	5.80^{e}	5.54^{cd}	57.7^{a}	5.68^{a}	1.25^{d}	6.20^{a}
Syn	63.1^{b}	14.6^{c}	63.0^{c}	6.31^{cd}	5.58^{bc}	50.8^{cde}	2.68^{bc}	1.64^{bc}	5.36^{bc}
SE	*0.66*	*0.53*	*1.0*	*0.03*	*0.02*	*0.55*	*0.25*	*0.14*	*0.17*

LINE ^{z}	Juiciness	Flavor	Tenderness	Palatability	Red ^{x}	Intermediate ^{x}	White ^{x}	Glycogen	GP
LW	5.01^{bcd}	6.14^{ab}	6.61^{b}	5.20^{cde}	7.2^{abc}	11.7^{abc}	81.1^{bc}	18.5^{b}	178.8^{bc}
Land	4.85^{cd}	5.93^{c}	6.06^{c}	4.88^{e}	7.5^{abc}	9.8^{c}	82.6^{ab}	17.3^{b}	172.1^{bcd}
Dur	5.46^{ab}	6.29^{a}	6.78^{ab}	5.46^{cd}	7.8^{abc}	11.1^{bc}	81.1^{bc}	22.4^{a}	189.6^{bc}
WDur	5.27^{abc}	6.22^{ab}	6.60^{b}	5.32^{cd}	7.8^{ab}	11.3^{bc}	80.8^{bc}	18.8^{b}	171.7^{bcd}
Hamp	5.28^{abc}	6.14^{ab}	6.75^{ab}	5.50^{bc}	6.3^{bc}	9.8^{c}	83.9^{a}	16.7^{bc}	169.1^{cd}
Berk	5.71^{a}	6.21^{ab}	7.04^{a}	5.83^{ab}	8.2^{a}	12.2^{ab}	79.6^{cd}	14.3^{c}	147.6^{e}
BH	5.72^{a}	6.25^{ab}	6.99^{a}	5.96^{a}	7.6^{abc}	10.9^{bc}	81.4^{abc}	17.0^{bc}	164.0^{d}
Piet-	4.59^{de}	6.17^{ab}	6.54^{b}	4.95^{e}	6.2^{c}	12.3^{ab}	81.5^{abc}	23.1^{a}	193.9^{a}
Piet+	4.36^{e}	6.09^{bc}	5.24^{d}	4.23^{f}	8.5^{a}	13.5^{a}	78.0^{d}	18.6^{b}	182.1^{b}
Syn	4.66^{de}	6.12^{ab}	6.44^{b}	5.11^{de}	8.3^{a}	10.6^{bc}	81.1^{bc}	17.1^{bc}	169.3^{cd}
SE	*0.17*	*0.07*	*0.14*	*0.14*	*0.6*	*0.8*	*1.0*	*1.1*	*4.0*

^{z} Large White (LW), Landrace (Land), Duroc (Dur), White duroc (Wdur), Hampshire (Hamp), Berkshire (Berk), Berkshire x Hampshire (BH), Pietrain Hal negative (Piet-), Pietrain Hal positive (Piet+), Synthetic (Syn).

^{x} % Area of specified fiber type.

^{abcde} Means within column bearing different superscripts differ ($P<0.05$).

Table 2. Correlations between several of the measured traits.

	Dissectible Lean	Backfat Depth	Lean Depth	pH, 45 min	pH, 48 hour	L*, 48 hour	Drip Loss	Intramuscular Fat	Shear Value	Juiciness	Overall Tenderness	Overall Palatability
Backfat Depth	-0.73											
Lean Depth	0.52	-0.36										
pH, 45 min	-0.43	0.37	-0.51									
pH, 48 hour	-0.23	0.32	-0.17	0.23								
L*, 48 hour	0.18	-0.07	0.44	-0.52	-0.39							
Drip Loss	0.35	-0.22	0.52	-0.68	-0.33	0.71						
IMF	-0.45	0.52	-0.30	0.24	0.22	0.02	-0.19					
Shear Value	0.16	-0.21	0.21	-0.28	-0.04	0.13	0.32	-0.21				
Juiciness	-0.31	0.25	-0.36	0.35	0.29	-0.25	-0.46	0.32	-0.25			
OA Tenderness	-0.30	0.29	-0.40	0.47	0.15	-0.27	-0.46	0.34	-0.40	0.60		
OA Palatability	-0.33	0.35	-0.39	0.45	0.24	-0.22	-0.36	0.36	-0.27	0.73	0.73	
GP	0.29	-0.32	0.26	-0.21	-0.63	0.34	0.35	-0.20	0.07	-0.25	-0.07	-0.13