Effect of breed and sex on growth, carcass and meat quality traits

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SUMMARY

A total of 431 pigs from three different breeds (DU=Duroc, LA=Landrace, YO=Yorkshire) and three genders (F=females, B=barrows, M=males) originating from 26 breeding farms on the Canadian Swine Improvement Program, were tested at the Deschambault test station in Québec. The pigs, tested in two batches, were measured for growth, feed efficiency, carcass and meat quality traits. On growth, feed efficiency and carcass traits, there were very little or no difference found among the three breeds available. Differences were found between sexes, such as a higher average daily feed intake for castrates compared to females and boars, but a better feed efficiency for boars. Boars had a higher lean yield and shoulder proportion in the carcass, while gilts showed the best dressing percentage, proportion of ham and loin eye area. On meat quality traits, especially in the loin, differences between breeds were found to be larger than differences between sexes, with, as expected, Duroc showing an overall better meat quality than white breeds, in terms of color, pH, marbling and drip loss. Some differences between sexes were also found, especially on marbling score. In conclusion, this test showed that in this sample of pigs, gender is an important source of variation for growth and carcass traits, while meat quality is more affected by breed.

INTRODUCTION

Several economically important traits are not recorded systematically in routine genetic improvement programs, such as feed efficiency, carcass characteristics and meat quality. Purebred station tests give opportunities to provide updated information on detailed characteristics of available breeds. In 2004 and 2005, purebred pigs from the Canadian Swine Improvement Program were tested at the Deschambault test station in Quebec, to study the impact of increasing slaughter weight on traits of growth, feed conversion, carcass and meat quality. In this test, purebred pigs from the main three Canadian breeds were tested, which gave the opportunity to draw a portrait of current Canadian pure breeds, and analyze breed and sex differences on more than 60 traits measured. The results are presented in this report for the main growth, carcass and meat quality characteristics.

MATERIAL

Purebred piglets from 26 farms on the Canadian Swine Improvement Program were sent to Deschambault test station. Two consecutive batches entered the station, in May and December 2004. They were monitored in nursery, individually identified with electronic tags and sent to the testing unit at approximately 28 kg live weight. Individual feed consumption was recorded during the entire test phase. Pigs were slaughtered at about 107 or 125 kg live weight and individually tracked at the slaughter plant for carcass measurements such as carcass length and weight, loin eye area and weight of primary cuts, and meat quality measurements such as pH, color and marbling scores, and drip loss. A detailed description of all the traits measured during the test is provided in Appendix 1.
Numbers of pigs available by breed and sex are presented in Table 1. In total, 431 purebred pigs from 26 farms had growth performances available till the end of the test. Among them, 428 had carcass data as well.

Table 1. Number of pigs by breed and sex

	Duroc	Landrace	Yorkshire	All breeds
Barrows	32	39	59	130
Gilts	36	41	87	164
Boars	27	41	69	137
All sexes	95	121	215	431

STATISTICAL ANALYSES

Data were analyzed using the MIXED procedure of SAS software (SAS Inst., Cary, NC). The model included batch, breed and sex effects and their interaction as fixed effects, farm of origin and pen within sex as random effects, and weight as a covariate when appropriate. For meat quality traits, the effect of slaughter date was added to the model as a fixed effect. The weight used in the model was either start or final weight for growth traits, hot carcass weight for carcass traits, and cold half-carcass weight for meat quality traits.

RESULTS

Growth and feed efficiency

From results shown in Table 2, there was no significant difference between breeds on growth traits, over all test or by phase. In some cases this might be because of the low number of pigs in the analysis. However, some trends are seen. For instance, Duroc and Yorkshire grew faster than Landrace on average, with a difference of about 15g/day. Feed intake and feed efficiency were very similar among breeds. Differences between sexes were much larger than differences between breeds for most traits, and very often significant. Barrows were faster growers (957 g/day) and gilts slower growers (885 g/day). Overall, barrows had a higher daily feed intake (2.42kg/day) compared to gilts (2.22 kg/day) and boars (2.13 kg/day). However there was no significant difference between females and boars after 75 kg live weight, whereas castrates had a higher daily feed intake on all phases. On average, boars were the most efficient feed converters (2.33 kg/kg) compared to barrows (2.57 kg/kg) and gilts (2.54 kg/kg). On this trait females and castrates were significantly different only on 30-50 and 50-75 kg phases. The differences between sexes observed on growth rate and feed efficiency are consistent with what was reported from the OPCAP project, and several other authors (Cisneros et al, 1996; Latorre et al, 2003; Mandell et al, 2006).

Table 2. Growth and feed efficiency – Least squares means

	Breed			Sex		
	Duroc	Landrace	Yorkshire	Barrows	Gilts	Boars
Off-test age (d)	166.0	166.1	164.7	161.8	169.4	165.6
Days on test (d)	97.0	97.3	95.6	92.8	100.4	96.7
ADG on test (g/day)	925.7	913.0	930.3	957.0a	885.0b	926.9a
ADG 30-50 kg (g/d)	851.4	850.6	870.9	902.1a	829.4b	841.5b
ADG 50-75 kg (g/d)	902.9	889.1	919.7	939.4a	859.1b	913.2a
ADG 75-100 kg (g/d)	917.8	928.2	940.7	956.8a	875.4b	954.5a
ADG 100-125 kg (g/d)	1027.4	1000.1	1030.4	1033.9	962.1	1061.9
Total feed intake (kg)	223.2	224.7	222.0	230.8	227.4	211.6
ADFI on test (kg/j)	2.25	2.25	2.27	2.42a	2.22b	2.13c
ADFI 30-50 kg (kg/d)	1.60ab	1.57a	1.63b	1.70a	1.61b	1.49c
ADFI 50-75 kg (kg/d)	2.17	2.19	2.22	2.40a	2.13b	2.06c
ADFI 75-100 kg (kg/d)	2.61	2.65	2.67	2.89a	2.53b	2.51b
ADFI 100-125 kg (kg/d)	2.91	2.89	2.92	3.14a	2.80b	2.77b
FCR on test (kg/kg)	2.46	2.49	2.48	2.57a	2.54a	2.33b
FCR 30-50 kg (kg/kg)	1.89	1.85	1.89	1.88a	1.95b	1.79c
FCR 50-75 kg (kg/kg)	2.44	2.48	2.43	2.59a	2.49b	2.27c
FCR 75-100 kg (kg/kg)	2.79	2.83	2.80	2.95a	2.84a	2.62b
FCR 100-125 kg (kg/kg)	2.83	2.90	2.86	3.04a	2.92a	2.63b

Breeds or sexes with shared subscripts or without subscripts do not differ significantly (P<0.05)
ADG=Average Daily Gain; ADFI=Average Daily Feed Intake; FCR=Feed Conversion Ratio

CARCASS TRAITS

Table 3 shows least squares means by breed and sex for the main carcass traits. There was no significant difference among breeds for dressing percent and lean yield, however Yorkshire

pigs tended to have carcasses with a slightly higher lean yield. Landrace pigs had the longest carcasses (84.4 cm) and Duroc pigs the shortest ones (82.0 cm).
Regarding the proportions of primal cuts (weights of primal cuts as a proportion of half-carcass weight), Duroc pigs had a significantly higher proportion of ham and shoulder and a lower proportion of belly and loin compared to white breeds. This is consistent with other results, for instance from the OPCAP project and Latorre et al (2003).
As observed for growth traits, observed differences between sexes were larger than differences between breeds. Females had the highest dressing percentage (79.3%) compared to barrows (78.6%) and boars (77.7%). Lean yield was higher for boars (62.1%), in relation to a lower backfat thickness compared to females and barrows. Gilts had the highest loin eye area (48.2%) and slightly more loin and ham, but less shoulder than barrows and boars. Boars had a higher proportion of shoulder but less belly in the carcass compared to gilts and barrows. Differences between females and castrates are well documented in different papers for several breeds and crosses (Armero et al, 1999; Mandell et al, 2006)

Table 3. Carcass traits – Least squares means

	Breed			Sex		
	Duroc	Landrace	Yorkshire	Barrows	Gilts	Boars
Hot carcass weight (kg)	91.0	90.6	90.8	90.7	91.4	90.3
Carcass Length (cm)	82.0a	84.4b	83.6c	82.6a	83.3b	84.1c
Dressing %	78.3	78.5	78.8	78.6a	79.3b	77.7c
Backfat Destron (mm)	17.23	17.43	16.38	19.10a	16.45b	15.48c
Muscle Destron (mm)	61.17	61.65	61.66	60.69a	63.00b	60.79a
Lean Yield (%)	61.28	61.21	61.73	60.41a	61.71b	62.10c
Loin eye area (cm^2)	46.32ab	45.15a	47.11b	44.16a	48.46b	45.96c
Half-carcass weight (kg)	39.4	39.5	39.7	39.6a	40.1b	38.9c
% Ham	27.17a	26.33b	26.56b	26.60a	26.95b	26.52a
% Loin	26.07a	27.07b	26.72b	26.56	26.85	26.46
% Shoulder	29.08a	28.38b	28.77a	28.60a	27.87b	29.76c
% Belly	17.68a	18.19b	17.94ab	18.27a	18.30a	17.23b

Breeds or sexes with shared subscripts or without subscripts do not differ significantly ($P<0.05$)

MEAT QUALITY

Adjusted means for several fresh meat quality traits measured on the loin and the ham are presented in Table 4. Unlike other traits previously presented, breed effects were found to be high on meat quality traits. Duroc is found to be significantly different from the white breeds on almost all traits analyzed. The loin meat from Duroc pigs is darker with a higher pH, more marbling and less drip loss, which is consistent with several other studies (Jeremiah et al, 1999; Mandell et al, 2006; Armero et al, 1999). Lower or no differences were found in the ham, although the technological yield is significantly higher in Duroc (126.4% vs 124.7 in Landrace and 125.7 in Yorkshire). There are some sex effects, although moderate, on meat quality traits. Boar meat was found to be darker and with less marbling and a higher pH, both in the loin and the ham. Barrows and females show no significant differences, except for loin marbling, higher in barrows (2.38 vs 2.11 on NPPC score).

Table 4. Meat Quality of Loin and Ham

	Breed			Sex		
	Duroc	Landrace	Yorkshire	Barrows	Gilts	Boars
Loin (*longissimus dorsi*)						
Ultimate pH	5.67a	5.55b	5.56b	5.59a	5.58a	5.62b
Reflectance (Minolta L*)	50.71a	53.32b	52.73b	52.89a	52.36ac	51.51bc
Color (Japanese scale)	2.82a	2.42b	2.52b	2.50	2.61	2.66
NPPC Marbling	2.57a	1.85b	1.87b	2.38a	2.11b	1.80c
Drips loss (%)	3.62a	5.74b	5.50b	5.06	5.06	4.74
Ham *(gluteus superficialis)*						
Ultimate pH	5.61	5.58	5.57	5.59	5.57	5.60
Reflectance (Minolta L*)	50.33	50.91	50.61	51.20a	51.24a	49.41b
Color (Japanese scale)	2.68	2.65	2.56	2.59	2.64	2.67
Technol. yield (%)	126.37a	124.73b	125.70a	125.14	125.73	125.93

Breeds or sexes with shared subscripts or without subscripts do not differ significantly (P<0.05)

CONCLUSIONS

Most of the results found in this study were consistent with the literature, and also with genetic trends observed in the Canadian breeds. On growth and carcass performances, it might seem unusual to see so little difference between sire and dam lines, when the latter are selected less strongly on production traits. However, Landrace and Yorkshire breeds are quite larger than the Canadian Duroc population, so even with less emphasis in the selection objectives on growth and carcass traits, higher selection intensities probably explain this result. In addition, some white breed lines are also selected as sire lines. Overall, the observed results are in agreement with recent realized genetic gains in the Canadian Swine Improvement Program.

This test provided valuable detailed results on intact males. Boars had a significantly better feed efficiency and lean yield compared to females and castrates, with small differences in meat quality, however this advantage is unlikely to be used by the industry, especially in a context of increasing slaughter weight. Solutions to reduce boar taint would have a large impact on production efficiency.

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APPENDIX 1

DEFINITION OF VARIABLES

Variables	Abbreviations (units)	Description
Nursery – Growth performance		
Initial age	*IAN (d)*	Age when entering the station
Final Age	*FAN (d)*	Age at the end of the adaptation period (nursery)
Duration	*DURN (d)*	Difference between final date of the adaptation period and admission date
Initial weight	*IWN (kg)*	Weight when entering the station
Final weigh	*FWN (kg)*	Weight at the end of the adaptation period
Average daily gain	*ADGN (g/d)*	For the total period and for each feeding period
Daily feed intake*	*DFIN (g/d)*	Daily feed intake per pig For the total period and for each feeding period
Total feed intake per piglet*	*TFIN (g/piglet)*	Total feed intake per pig For the total period and for each feeding period
Feed efficiency (for live animal weight gain)*	FEN (live weight gain)	Feed intake for all the pigs / Total live weight gain of all the pigs For the total period and for each feeding pedriod
Test period – growth performance		
Age at beginning of test	*IAT(d)*	Age at beginning of test
Age at end of test	*FAT (d)*	Age on slaughterhouse shipment day, before starving
Duration of test	*DURT (d)*	Difference between date of end of test and date of beginning of test
Weight at beginning of test	*IWT (kg)*	Weight at beginning of test
Weight at end of test	*FWT (kg)*	Weight on slaughterhouse shipment day, before starving phase
Average daily gain	*ADGT (kg/d)*	Final weight – Initial weight / number of days pig stayed in station For the total period and for each feeding phase
Repeated measurements		
Backfat thickness	*BFT (mm)*	Measurement of back fat between 3rd and 4th last ribs on live animals Frequency: at 50 kg, 75 kg, and every other week after 75 kg until slaughtering. Instruments: A mode and B mode Operators: at least two operators for each instrument.
Loin depth	*LD (mm)*	Measurement of loin depth between 3rd and 4th last ribs on live animals Frequency: at 50 kg, 75 kg, and every other week after 75 kg until slaughtering. Instruments: A mode and B mode Operators : at least two operators for each instrument.
Intramuscular fat	%IMF	Measurement of intramuscular fat content using a mode B ultrasonic equipment
Loin eye area	LEA	Measurement of loin area using a mode B with a transversal measurement.
Feed intake performance		
Total feed intake per pig	*TFI (kg)*	Total feed intake of pig during test
Daily feed intake per pig	*DFI (kg/d)*	Total feed intake of pig during test / duration of test For the total period and for each feeding phase
Feed efficiency (on live animal weight gain)	FE (kg/kg)	Feed intake of pig / weight gain (live weight) For the total period and for each feeding phase

Carcass traits		
Hot carcass weight	*HCW (kg)*	Hot carcass weight after exsanguination and evisceration, including the head, tongue, leaf fat, kidneys, and front and hind feet
Carcass yield	*CY (%)*	(Hot carcass weight / live weight at end of test) x 100
Classification index	*Average index*	Index calculated from the carcass sorting grid
Classification Index 80-91,9 kg	*Index 80 – 91.9 kg*	Index defined for this weight range
% pigs in the 80-91.9 kg range	*% pigs 80-91.9 kg*	% pigs in this weight range
Classification Index 80 – 84,9 kg	80 - 84,9 kg Index	Index defined for this weight range
Classification Index 85 – 91,9 kg	85 - 91,9 kg Index	Index defined for this weight range
Lean yield	*LY (%)*	Lean yield of the carcass calculated from the prediction equation established by Agriculture and Agri-Food Canada
Carcass length	CL (cm)	Measured on the cold carcass, from the cranium edge of the first rib to the anterior tip of the aitchbone (using a Foster Gauge ruler)
Fat thickness - ruler		Measurement taken on the loin, after cutting, between 3rd and 4th last ribs
Muscle thickness - ruler		Measurement taken on the loin, after cutting, between 3rd and 4th last ribs

* Feed intake in the nursery section is measured for all the pigs and not on an individual basis.

Variables	Abbreviations (units)	Description
Primary carcass cut		
Half-carcass weight	HCW (kg)	Half-carcass weight calculated from the 5 primary cuts and of other parts (jowl, tail, hock, front and back feet), without adding weight of leaf fat, kidney, or head. The weights of the jowl, tail and the front and back feet are subtracted.
Loin eye area	*LEA (cm²)*	Surface measured with a planimeter
Weight of ham	*HAMW (kg)*	Cut perpendicular to the lower part of the leg. Cut line 4.5 cm (1 ¾ in.) from the internal apex of the pubian bone. Without rear foot or tail.
Weight of loin	*LOINW (kg)*	The loin is separated from the belly by sawing along a line starting 4.5 cm (1 ¾ in.) from the base of the ribs, reaching 10 cm (4 in.) out at the middle of the loin and ending parallel to the tenderloin at the top of the leg, at a distance of 2 cm (3/4 in.).
Weight of shoulder	*SHW (kg)*	To be measured as the primal-cut shoulder (bone in, skin and fat on). Shoulder is removed by cutting at right angles to the back through the joint between the 3rd and 4th thoracic vertebrae.
Weight of hock	*HOW (kg)*	Withdrawn by making a cut parallel to the top of the belly side of the shoulder at the centre of the joint to expose the figure of 8 bone. The front foot is cut away through the middle of the joint.
Weight of picnic ham	*PICW (kg)*	Anterior part of the shoulder. The shoulder is cut away from the loin and the belly along a line perpendicular to the back. The shoulder is then separated in two parts by cutting 2 cm (3/4 in.) away from the backbone. Without hock or front foot.
Weight of shoulder butt	SHBW (kg)	Dorsal part of the shoulder. Without jowl.
Weight of belly	*BEW (kg)*	Same description as for loin.
% of ham weight in the half carcass	*HAM% (%)*	(Weight of leg / weight of ½ carcass) x 100
% of loin weight in the half carcass	*LOIN% (%)*	(Weight of loin / weight of ½ carcass) x 100
% of shoulder weight in the half carcass	*SH% (%)*	(Weight of shoulder/ weight of ½ carcass) x 100
% of belly weight in the half carcass	*BE% (%)*	(Weight of belly / weight of ½ carcass) x 100

Variables	Abbreviations (units)	Description
Meat quality traits		
Loin: measured on longissimus dorsi *between the 3rd and 4th last ribs, 18 to 24 hours after slaughtering*		
Ham: measured on different muscles, 18 to 24 hours after slaughtering		
Ultimate pH (loin and ham)	pHu	Measured at two points in the loin muscle using a pH meter. The ham measurement is taken at the level of the *gluteus superficialis* muscle.
Minolta color (loin and ham)	*L*, a*, b**	Measurement of the reflectance taken at two points in the loin muscle using a Minolta 300CR instrument. The ham measurement is taken at the level of the *gluteus superficialis* muscle.
Visual evaluation of the colour (loin and ham)	*COL*	Evaluation by comparing to colour spots of the Japanese scale (from 1 to 16). For the ham, this evaluation is carried out in *gluteus superficialis* muscle.

Visual evaluation of intramuscular fat in the loin	*MARB*	Measurement of the amount of marbling according to the scale (from a to e) defined by Agriculture and Agri-Food Canada and/or the NPPC scale (from 1 to 10).
Loin Drip loss	*LDL (%)*	Measurement taken on a sample of muscle from the front part of the loin, after letting it drip 24 to 48 hours. (Drip loss of the muscle / weight of the fresh muscle) x 100
Ham technological yield	*HTY (%)*	Estimated from a prediction equation using variables describing the colour and reflectance (L*, a* and b*) of the ham muscles. Measurements made on *gluteus superficialis* and *gluteus profondus* muscles.

Evaluation of loin muscular fibres	Number, size, type	Histochemical evaluation of the number, size and type of muscular fibres (cost to be defined)
Visual evaluation of steatosis in leg	*STEAT*	Measurement of the degree of steatosis using the CDPQ scale (from 0 to 5) conducted inside the leg at the level of the *semi-membranous*, *semi-tendinous* muscles and of *biceps femoris* (cost to be defined)
Evaluation of fat content	*FA (%)*	Evaluation of the fatty acid profile of sub-cutaneous fat, using solvent extraction and gas chromatography (cost to be defined)

Halothane genotype	Analysis carried out on a blood sample
RN genotype	Analysis carried out on a blood sample

Analysis of meat quality : sample of 108 pigs (12 pigs per breed and sex for the slaughtering weight of 107 kg)
Number, size and type of fibres (loin)
Enzymatic activity (loin)
Glycolytic potential (loin)
Total soluble protein*
Muscle composition (loin)*
Shear force*
Micro-ham (semi-tendineux)

* these measurements will be done for both slaughtering weights (107 and 125 kg)