Differences among Genotype and Gender for Growth, Carcass Composition and Meat Quality[1]

Ronald O. Ball

Dept Agricultural, Food & Nutr. Science, University of Alberta, Edmonton AB T6H 2P5
Email: rball@afns.ualberta.ca

▪ Introduction

There are many growth and carcass characteristics of pigs that contribute to the overall profitability of the pork production system. The competitiveness of the Canadian pork industry depends upon optimum combinations of growth, carcass characteristics and meat quality to meet diverse market demands. Many of the economically important characteristics of pigs are genetically determined, therefore, informed choice of the optimum genotype is required.

Some information on genotype characteristics is available from previous research. However, genotype characteristics are not fixed. Characteristics can vary among sources of the same genotype of pigs from different parts of the world or even among different breeders or multipliers within a local area. Differences among genotypes and herds also change over time as breeders or breeding stock companies pursue diverse selection goals with varying degrees of success.

Currently, the large multinational breeding companies dominate the market for breeding stock in Canada. However, the principles of how to use differences between genotype is the same whether the genotype being described is provided by smaller independent purebred breeders or large companies. The purpose of this paper is to describe the variation that can exist between genotypes and discuss how to take advantage of this to produce pigs for diverse markets.

[1] This article was excerpted from "Differences Among Breeds, Breed Origins and Gender for Growth, Carcass Composition and Pork Quality", Ontario Pork Carcass Appraisal Project Final Report, by R.O. Ball, J.P. Gibson, C.A. Aker, K. Nadarajah, B.E. Uttaro and A. Fortin (1996)

The Ontario Pork Carcass Appraisal Project (OPCAP) was initiated by Drs Brian Kennedy, Gordon Bowman and Ron Ball to document differences among the four principal pig breeds in Canada. Breeding stock came from 118 different breeding herds representing 57 different seedstock producers. This provided a unique opportunity to estimate the amount of variation among breeding stocks within a breed. The large data set also allowed analyses of breed by sex interactions.

This article summarizes the differences among breeds (Yorkshire, Landrace, Duroc, Hampshire) and gender (boar, gilt, barrow) for the main growth and carcass characteristics and selected measures of pork quality. These differences are discussed in relation to the variation observed among different sources of breeding stock.

▪ Methods

Description of the trial protocols, carcass dissection and statistical methods are given in the Ontario Pork Carcass Appraisal Project Final Report (1996).

A large number of differences were examined in this experiment however, only the key breed and sex effects will be discussed. Additional results are summarized in Tables 1 and 2.

▪ Genotype Differences in Growth Performance and Carcass Lean Yield

Significant differences were observed among breeds for most of the live animal traits (Table 1a). Of particular interest, Landrace pigs had the fewest days to 100 kg and highest average daily gain, while Hampshire pigs required the most days to 100 kg. Yorkshire pigs had the lowest backfat depth, though this was only about 1 mm less than the fattest breeds, Durocs and Landrace.

Carcass yield, as estimated from the grading probe, appears in two ways because the grading system changed in the middle of the experiment. Carcass index is shown with two different analyses; one uses weight as a covariate because slaughter weight differed slightly between breeds and genders. Differences in estimated carcass yield and carcass index among the breeds were small.

Table 1a. Least square means for breed [1,2,3]

	Breed			
Trait	**Duroc**	**Hampshire**	**Landrace**	**Yorkshire**
Age on test, d	80.5^{a}	81.5^{a}	77.5^{b}	79.0^{ab}
Weight on test, kg	31.8^{ab}	32.7^{a}	34.5^{b}	31.3^{b}
Weight at slaughter	107.4^{a}	105.1^{b}	107.1^{a}	105.4^{b}
Days to 100 kg	157.9^{a}	165.5^{b}	154.9^{c}	161.3^{b}
Average daily gain, kg/d	0.894^{a}	0.811^{b}	0.899^{a}	0.858^{c}
Backfat at 100 kg, mm	13.89^{a}	13.21^{ab}	13.83^{a}	12.88^{b}
Feed conversion	2.63	2.69	2.65	2.61
Hot carcass wt, kg	84.4^{ab}	83.0^{a}	84.9^{b}	84.1^{a}
Cold carcass wt, kg	75.3	74.3	76.2	75.3
Dressing %	78.5^{a}	78.9^{a}	79.0^{a}	79.5^{b}
Estimated yield (old), %	51.0^{ab}	50.9^{ab}	51.0^{a}	51.4^{b}
Estimated yield (new), %	60.4	60.7	61.1	60.8
Carcass index:				
- no covariate	106.3^{ab}	107.7^{ab}	105.9^{a}	107.7^{b}
- slaughter wt covariate	107.1	107.3	106.5	107.3
Carcass length, cm	81.5^{a}	81.0^{a}	84.5^{b}	83.2^{c}
Moisture loss, %	1.28	1.36	1.25	1.29
Max. fat depth shoulder, mm	42.9^{a}	38.1^{b}	39.4^{b}	40.2^{b}
Min. backfat, mm	20.9^{a}	21.1^{a}	20.4^{a}	20.3^{a}
Min. loin fat, mm	26.7	25.6	26.3	25.9
Loin eye are, cm^2	40.1^{a}	45.6^{b}	41.3^{a}	42.9^{c}
Lean content of shoulder, %	46.9^{a}	47.0^{ab}	47.9^{b}	48.1^{b}
Lean content of loin, %	50.4^{a}	52.2^{ab}	50.5^{a}	52.1^{b}
Lean content of ham, %	60.8^{a}	61.8^{a}	61.1^{a}	63.4^{b}
Lean content of 3 primals, %	52.5^{a}	53.4^{ab}	53.0^{a}	54.3^{b}
Chemical fat loin, % of DM	18.2^{a}	16.9^{ab}	15.5^{b}	16.2^{ab}
Chemical protein loin, % DM	11.9^{ab}	11.6^{a}	12.2^{b}	12.2^{b}
Chemical fat belly, % of DM	60.6^{a}	62.4^{ab}	68.3^{b}	63.4^{a}
Chemical protein belly %DM	5.2^{a}	5.1^{ab}	4.4^{a}	5.2^{a}
Loin drip loss, %	10.2^{a}	14.2^{b}	12.1^{c}	11.7^{c}
Ham drip loss, %	10.5^{a}	14.1^{b}	8.0^{c}	9.5^{d}
Marbling score, loin	2.92^{a}	1.78^{b}	1.78^{b}	1.71^{b}
Ag Canada colour, loin	2.85^{a}	2.63^{abc}	2.41^{b}	2.62^{c}
Japan colour, loin	3.52^{a}	3.40^{ac}	3.11^{b}	3.35^{c}
Ag Canada structure, loin	2.94^{a}	2.41^{bc}	2.39^{b}	2.57^{c}
Ag Canada colour, ham	3.10^{a}	2.52^{b}	3.60^{c}	3.47^{d}
Ag Canada structure ham	2.83^{a}	2.25^{b}	2.86^{a}	2.78^{a}

Table 1b. Least square means for sex [1,2,3]

Trait	Sex		
	Barrow	**Gilt**	**Boar**
Age on test, d	79.9	79.9	79.1
Weight on test, kg	31.9	31.9	31.6
Weight at slighter	105.5[a]	103.8[b]	109.4[c]
Days to 100 kg	157.9[a]	164.0[b]	157.7[a]
Average daily gain, kg/d	0.888[a]	0.823[b]	0.886[a]
Backfat at 100 kg, mm	15.22[a]	13.19[b]	11.94[c]
Feed conversion	2.74[a]		2.46[b]
Hot carcass wt, kg	83.4[a]	82.3[b]	86.6[c]
Cold carcass wt, kg	74.7[a]	73.8[a]	77.4[b]
Dressing %	79.0[b]	79.4[a]	78.5[b]
Estimated yield (old), %	50.0[a]	51.5[b]	51.7[b]
Estimated yield (new), %	59.5[a]	61.4[b]	61.4[b]
Carcass index:			
- no covariate	105.6[a]	109.5[b]	105.6[a]
- slaughter wt covariate	105.3[a]	108.0[b]	107.9[b]
Carcass length, cm	81.6[a]	82.4[b]	83.6[c]
Moisture loss, %	1.27	1.28	1.32
Max. fat depth shoulder, mm	42.8[a]	40.5[b]	37.1[c]
Min. backfat, mm	23.9[a]	20.4[b]	17.8[c]
Min. loin fat, mm	29.3[a]	26.6[b]	22.3[c]
Loin eye are, cm^2	39.8[a]	44.4[b]	43.2[c]
Lean content of shoulder, %	45.9[a]	47.8[b]	48.6[c]
Lean content of loin, %	47.7[a]	52.1[b]	54.0[c]
Lean content of ham, %	59.4[a]	62.3[b]	63.6[c]
Lean content of 3 primals, %	50.8[a]	54.0[b]	55.1[c]
Chemical fat loin, % of DM	18.8[a]	16.4[ab]	14.7[b]
Chemical protein loin, % DM	11.7[a]	12.0[b]	12.2[b]
Chemical fat belly, % of DM	70.6[a]	63.1[b]	57.4[c]
Chemical protein belly %DM	4.0[a]	5.0[b]	6.1[c]
Loin drip loss, %	11.8[a]	12.6[b]	11.7[a]
Ham drip loss, %	10.9[a]	11.4[a]	9.2[b]
Marbling score, loin	2.32[a]	1.97[b]	1.84[c]
Ag Canada colour, loin	2.60[ab]	2.70[a]	2.60[b]
Japan colour, loin	3.32	3.34	3.37
Ag Canada structure, loin	2.62	2.59	2.53
Ag Canada colour, ham	3.08[a]	3.18[ab]	3.25[b]
Ag Canada structure ham	2.64	2.66	2.75

Estimated carcass yield is not a good measure of carcass leanness, which is better estimated by dissected lean content of the three primal cuts. Breed differences in lean % in three primals were somewhat larger than for carcass yield, with Yorkshires (54.3%) being well ahead of Hampshires (53.4%), and Durocs having the lowest yield (52.5%).

Different breed rankings were observed for lean content of each of the three primals separately (lean content of shoulder, of loin and of ham %) and this was reflected in the distribution of lean as estimated by shoulder lean, loin lean and ham lean (% of three primals). Durocs had the highest proportion of lean in the ham (38.9%), while Landrace had the lowest (37.3%). Conversely, Landrace had the highest proportion of lean appearing in the loin (31.1%); Durocs and Hampshires had the lowest (30%).

Implications of Differences in Lean Yield

The differences among genders and breeds in dissected lean content of the primal cuts are much larger than the differences predicted by the estimated lean yield equations (old and new) and carcass index. This means the current grading system severely underestimates differences between animals in lean yield.

There is a very significant economic implication of inaccurate lean yield equations for superior pigs. This means that differences between genotypes may not be accurately reflected in the standard grading equations. Whenever possible producers that use pigs with high lean yields, or with important economic differences in lean distribution (ie large hams), should consider negotiating contracts designed to more accurately reward the actual lean yield and lean distribution of their pigs.

▪ Genotype Differences in Meat Quality

Meat quality was estimated by drip loss and subjective scores for marbling, colour and structure (Tables 1a & 1b). Taste panel assessments of meat quality were also obtained. Drip loss, an inverse measure of water holding capacity, was highest for the Hampshire pigs. The high drip loss of Hampshire pigs suggests that the Napole gene was probably at high frequency in the Ontario Hampshire population. Duroc pigs consistently had the highest values for marbling score, and colour and structure of the loin, while Landrace scored lowest for colour and structure of loin. However, the Landrace had the highest colour score for ham. Higher values for colour and structure indicate darker and firmer appearance of the pork.

Implications of Differences in Meat Quality.

Meat quality is an important economic characteristic for the packer and processor. Much of the variation in meat quality that occurs is a result of preslaughter handling of the pigs and immediate post slaughter handing of the carcass, and therefore is the packer's responsibility. However, there are many pork quality characteristics that can be genetically influenced and others that can be influenced by the on-farm nutrition program (de Lange, et al. 1999). Many packers and processors will consider contracts with bonuses for meat quality. For this reason, producers should be choosing breeding stock based on meat quality characteristics, as well as growth performance. Nutrition programs are available to improve colour, reduce PSE pork, improve shelf life, and maximize lean yield; and these should be used when profitable contracts for these characteristics can be negotiated.

▪ Differences among Barrows, Gilts and Boars

The typical and well-known differences among the genders for growth performance were confirmed, with boars having a large advantage in terms of backfat, feed efficiency and lean yield (Table 1a & 1b). Feed efficiency for barrows and gilts is equal only because the experimental protocol penned barrows and gilts together. Boars consistently outperformed barrows, but were often similar in performance to gilts. Lean content of the primals was highest for the boars. Particularly striking was the large difference of 6.3 percentage units between boars and barrows in percent lean of the loin. Boars also had dramatically leaner bellies than barrows, with gilts being intermediate.

There were fewer and smaller differences between the genders for meat quality measurements than for performance and carcass measurements (Table 1a & 1b). The largest difference in the meat quality measurements was a higher marbling score for barrows.

Implications of Differences between Genders.

Attention should be drawn to the relative differences between the breeds versus the genders. In most cases, the differences between the highest and lowest gender for any particular trait, was much greater than the difference between the highest and lowest breed. These data reinforce the need to use split-sex feeding programs combined with separate marketing programs for barrows and gilts to optimize grading results, and thus financial return.

▪ How Much Variation is There Between Herds Within A Breed?

Table 2 provides a comparison of the variation that exists between breeding stocks within a breed compared to the differences between breeds. These are unique data because there has not previously been a data set large enough and with a sufficient number of herds to clearly demonstrate these differences in carcass and meat quality traits.

The breed range in Table 2 shows the difference between the means (from Table 1a) for the top and bottom breeds for each trait. To illustrate the variation among herds as sources of breeding stock, we have presented the estimated difference between the top versus the bottom 10% of herds. We have assumed that there is similar variation within each breed. As an example, the difference between the top and bottom breeds for days to 100 kg was 10.6 days (Hampshire versus Landrace, from Table 1a) while the differences between the top 10% and bottom 10% of herds was estimated to be 14 days. This indicates that there is slightly more opportunity to improve days to 100 kg by using pigs from the best herds within a breed than by choosing between breeds. This is indicated by the ratio of herd range to breed range in Table 2. Where this ratio is greater than one, the difference between herds within a breed is greater than the difference between the best and worst breed for that trait.

There were some very large differences in this ratio for the performance and carcass yield traits. For example, the ratio for backfat was 3.36, which indicates that even for the fattest breed, there are breeding stocks which are considerably leaner than the average for the leanest breed. Other traits with high herd to breed ratios were estimated yield, carcass index, minimum backfat, minimum loin fat, and lean content of each of the three primal cuts.

Analyses of the meat quality traits indicated that there is considerably more variation between breeds than within a breed for meat quality. Thus, if the goal is lower drip loss, better colour, and firmer structure, it is most important to choose the right breed or genotype.

▪ Conclusion

These differences among and within genotypes allows producers to select different genotypes to match specific production and marketing niches

For many of the performance and carcass characteristics there was more variation between herds than between breeds. This means that when choosing

Table 2. Variation between herds relative to variation between breeds.

Trait	Breed Range[1]	Top vs Bottom 10% of Herds[2]	Ratio of Herd Range to Breed Range[3]
Age on test, d	4.0^{*}	15.3^{***}	3.8
Weight on test, kg	3.2^{**}	1.1^{ns}	0.35
Weight at slaughter	2.3^{***}	2.2^{ns}	0.94
Days to 100 kg	10.6^{***}	14.0^{***}	1.32
Average daily gain, kg/d	0.088^{***}	0.087^{**}	0.99
Backfat at 100 kg, mm	1.01^{**}	3.40^{***}	3.36
Feed conversion	0.08^{ns}	0.24^{***}	3.06
Hot carcass wt, kg	1.9^{*}	1.5^{ns}	0.79
Cold carcass wt, kg	1.9^{ns}	1.6^{ns}	0.83
Dressing %	1.0^{***}	1.2^{ns}	1.20
Estimated yield (old), %	0.9^{ns}	1.9^{***}	2.07
Estimated yield (new), %	0.7^{ns}	2.6^{**}	3.71
Carcass index (old)	1.8^{**}	3.3^{ns}	3.65
Carcass length, cm	3.5^{***}	2.2^{***}	0.62
Moisture loss, %	0.11^{ns}	0.05^{ns}	0.47
Skin thickness, loin, mm	1.0^{ns}	0.7^{ns}	0.73
Max. fat depth shoulder, mm	4.8^{***}	4.1^{**}	0.85
Min. backfat, mm	0.8^{ns}	4.2^{***}	5.19
Min. loin fat, mm	2.1^{ns}	5.7^{***}	2.70
Loin eye are, cm^2	4.5^{***}	6.9^{***}	1.43
Lean content of shoulder, %	1.2^{**}	3.3^{***}	2.73
Lean content of loin, %	1.8^{***}	5.6^{***}	3.10
Lean content of ham, %	2.6^{***}	3.8^{***}	1.44
Lean content of 3 primals, %	1.8^{***}	4.1^{**}	2.26
Chemical fat loin, % of DM	2.7^{*}	3.4^{ns}	1.24
Chemical protein loin, % DM	0.6^{*}	0.4^{ns}	0.61
Chemical fat belly, % of DM	7.7^{**}	8.4^{*}	1.09
Chemical protein belly %DM	0.8^{**}	1.2^{**}	1.50
Loin drip loss, %	4.0^{***}	2.1^{*}	0.53
Ham drip loss, %	6.1^{***}	2.6^{*}	0.42
Marbling score, loin	1.21^{***}	0.54^{**}	0.45
Ag Canada colour, loin	0.44^{***}	0.24^{ns}	0.54
Japan colour, loin	0.41^{***}	0.25^{ns}	0.61
Ag Canada structure, loin	0.55^{***}	00.13^{ns}	0.26
Ag Canada colour, ham	1.08^{***}	0.42^{*}	0.39
Ag Canada structure ham	0.61^{***}	0.35^{*}	0.59

breeding stock it is often more important to identify the best breeding stock within a breed, or the best lines within a genotype, than to identify the best breed overall.

The gender differences strongly emphasize the need to tailor the production and marketing system to take advantage of the gender differences, where these are advantageous, and minimize the differences where these are disadvantageous.

Collectively, these results show the advantage of conducting a large and comprehensive analysis of carcass and meat quality traits. Although many large projects have been conducted to evaluate growth performance traits, few comprehensive programs have been completed for carcass and meat quality. Unfortunately similar data are not available for the genotypes that are currently in widespread use in western Canada.

▪ References

C. de Lange, B. Uttaro and I. Mandell. 1999. *Nutritional Means to Enhance Carcass and Meat Quality in Pigs.* In: Proceedings of the 20th Western Nutrition Conference, D. Korver, ed., p. 167-174. Published by Dept Agricultural, Food & Nutritional Science, Univ. Alberta, Edmonton, AB.

R.O. Ball, J.P. Gibson, C.A. Aker, K. Nadarajah, B.E. Uttaro and A. Fortin 1996. *Differences Among Breeds, Breed Origins and Gender for Growth, Carcass Composition and Pork Quality*. In: Ontario Pork Carcass Appraisal Project Final Report, p. 12-20. Ontario Swine Improvement, Guelph, ON.

Notes for Tables 1a & 1b:

[1] From analyses including breed, sex and PSS status and all two-way interactions. Details of analyses given in Ball et al. (1996).

[2] Breeds or sexes with shared superscripts or without superscripts do not differ significantly (P>0.05).

[3] Analyses for the first eight traits (i.e. age on test to hot carcass weight) and carcass index (no covariate) did not include hot carcass weight as a covariate. Analysis of carcass weight (slaughter weight covariate) included slaughter weight as a covariate.

Notes for Table 2:

[1] Difference between highest and lowest performing breed for each trait.

[2] Predicted difference between top 10% and bottom 10% of breeders, assuming between herd variation is the same for all breeds.

[ns, *, **, ***] Indicates statistical significance of breed range and between herd variation; ns = not statistically significant, * = P<0.05, ** = P<0.01 or *** = P<0.001.

[3] A ratio greater than 1.0 indicates that the predicted difference between the best and worst breed for that trait.