Variation and trends for weight of individual carcase cuts

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Introduction

In France more than 25 million pigs were slaughtered in 2007. Most of the pigs are a three-breed cross with Pietrain boars or synthetic sire lines mated to crossbred sows (mainly Large White cross Landrace). The classification of pig carcases is based on one or two fat depth and one muscle depth measurements to estimate the total lean meat percentage of the four main cuts. More than 90% of carcases are classified with the manual probe CGM (Meagre Grease Captor – reflectance measurements). In comparison, approximately 5 million pigs are slaughtered each year in Australia. The Australian payment system is based on carcase weight and P2 fat depth.

In pig production, genetic selection and rearing conditions have greatly improved body composition towards a higher lean meat content and a lower fat deposition. For nearly 50 years animals have been selected for high growth and lean meat percentage. In France, selection for carcase composition has always been based on an estimation of carcase lean meat content, either by backfat to muscle depth ratios or by partial dissections. However, the weight and composition of primal cuts has not been targeted by selection directly. This article aims to review the differences in carcase composition between breeds and to analyse phenotypic trends for lean meat percentage and the weights of main cuts over ten years.

History of French breeding goals

Since the 1960s independent breeders and pig breeding organisations have based animal selection on growth and carcase composition. On farm, backfat depth measurements enabled lean meat content to be estimated. Between 1986 and 1995 young boars and their relatives were tested in central testing stations and slaughtered in order to obtain carcase conformation and meat quality data. Since 1994, BLUP methodology has been used to estimate breeding values. For reasons of health and on farm sanitation, central pig testing stations halted testing of young boars in 1995. Testing stations now will only accept siblings of on farm AI candidates. These animals are all slaughtered. On farm, in addition to backfat depth, measurements of muscle depth are also recorded since about ten years ago.

Selection for lean meat percentage is based on backfat and muscle depth measured on farm and estimated lean meat content measured on siblings in central test stations. The prediction for lean meat content is based on the weight of the loin and ham as well as the weight of the subcutaneous fat above the loin.

Data description and analysis

This study used data from all pure breed siblings recorded between 1999 and 2007 in the French national breeding scheme. Three test stations were used: Argentré, Le Rheu and Mauron. The French national scheme has two dam lines, Landrace Français (LF) and Large White dam line (LWF), and two sire lines, Large White sire line (LWM) and Pietrain (PP). Only one sex per breed is recorded in test stations (Table 1). Pigs are performance-tested in groups of 12 animals and given *ad libitum* access to feed.

Table 1. Number of records by breed, sex and average net carcase weight (NCW, cold carcase weight)

Breed	**LF**	**LWF**	**LWM**	**PP**
N	7386	11803	2714	2400
Sex	Castrate	Castrate	Castrate	Female
NCW (kg)	80.6	81.8	82.8	84.3

LF: Landrace Français; LWF: Large White dam line; LWM: Large White sire line; PP: Pietrain

Pigs were slaughtered at 110 kg body weight on average. Carcases were allowed to chill for approximately 24 hours. All carcases were dissected according to commercial procedures (Métayer and Daumas, 1998). Carcases were divided into four primal cuts. The weight of the loin with the skin removed and fat trimmed, skin-on ham, shoulder and belly were obtained from one side. Furthermore, the weight of fat and rind above the loin (backfat) was also recorded. The length was measured between the pubic symphysis and atlas.

Least square means for length and primal cut weights and allometric coefficients for primal cut weights against net carcase weight were estimated using the GLM procedure of the SAS analytical system (SAS, 1999). The following model was used for all traits:

$$Y_{ijkl} = BREED_i + YEAR(BREED)_j + STABATCH(YEAR)_k + b*NCW_l + e_{ijkl}$$

Where Y_{ijkl} = trait under study; $BREED_i$ = fixed effect of i^{th} breed (4 classes); $YEAR(BREED)_j$ = combined effect of j^{th} year and breed (37 classes); $STABATCH(YEAR)_k$ = combined effect of the k^{th} batch station and year (151 classes); NCW = the l^{th} net carcase weight (kg) as a covariate; b = linear regression coefficient of Y on net carcase weight; e_{ijkl} = residual effect.

Net carcase weight, length, fat and muscle depth contribution to weight of each primal cut was regressed using the REG procedure of SAS.

Results and discussion

1. Between-breed variability

Least squares means by breed for length and primal cut variables are listed in Table 2. Each of the primal cuts was reported as the weight of one side of the carcase. Percentage calculations were obtained by taking primal cut weight as a percentage of half carcase weight. All differences between breeds were significant (p<0.001). Pietrain animals had the shortest bodies and Landrace the longest. Pietrain progeny had larger ham averages, greater loin percentages and less backfat weight than the three other breeds (-2.4% with LWM and -4.5% with LF). Landrace pigs had a higher belly and backfat weight as a percentage of their carcase weight. Large White pigs (sire and dam lines) had the heaviest shoulders.

In 1998, the Large White breed was divided into two distinct lines, the Large White dam line and Large White sire line. In order to differentiate between those two lines, a higher weight on lean meat content was used in the sire line selection index. Thus over ten years, significant differences between the Large White dam line and the Large White sire line have evolved. Animals from the sire line have a greater overall lean meat percentage accompanied by higher ham, loin and shoulder weights. In addition, weights and percentages for the belly and backfat were lower.

Table 2. Least squares means by breed for length, carcase weight and primal cut measurements (weight of one side and proportion of carcases weight)

		Dam lines		Sire lines	
Traits	**Units**	**LF**	**LWF**	**LWM**	**PP**
Length	mm	1023	1006	981	942
ELMC	%	52.43	54.59	56.84	64.58
Ham	kg	9.40	9.51	9.70	10.95
	%	24.46	24.79	25.26	28.38
Belly	kg	5.07	4.84	4.66	4.25
	%	13.16	12.59	12.12	10.99
Shoulder	kg	8.83	9.10	9.18	8.78
	%	22.98	23.71	23.92	22.72
Loin	kg	10.14	10.40	10.72	11.50
	%	26.37	27.09	27.91	29.76
Backfat	kg	3.73	3.28	2.91	2.01
	%	9.69	8.51	7.56	5.19

ECLM: estimated lean meat content; LF: Landrace Français; LWF: Large White dam line; LWM: Large White; PP: Pietrain

2. Efficiency of selection: phenotypic trends

A stronger selection emphasis was placed on lean meat percentage in sire lines in comparison to dam lines. Ultrasonic backfat measurements are taken for all animals tested on farm. Loin depth is only measured in sire lines.

Lean meat content was stable in dam lines (+0.04% per year) and was improved in sire lines by +0.41% in LWM and + 0.16% in PP per year (Figure 1). The phenotypic trends for backfat weight showed a decrease of 760 g in LWM and 523 g in PP. In dam lines, this reduction in backfat was lower but remained in accordance with breeding goals. Indeed, too much decreased fatness may have its own consequences, especially on sow productivity. Since 2002, an increase in loin weight was observed in both sire lines. The phenotypic trends for ham and shoulder weights were zero to slightly positive, except in LWM where, since 2001, a slight increase in ham weights were observed. Concerning belly weight, improvement in sire lines is lacking. In contrast, an improvement of more than 200 g was observed in dam lines. These results are similar to those reported in a French study by Bazin et al. (2003) who did not find ham weight differences between LWF and LF progeny from 1977 and 2000. Bazin et al. (2003) showed significant annual genetic trends for estimated lean meat content, which mainly resulted from a decrease in backfat weight and an increase in loin weight in both breeds. Backfat and muscle depth are both recorded on farm.

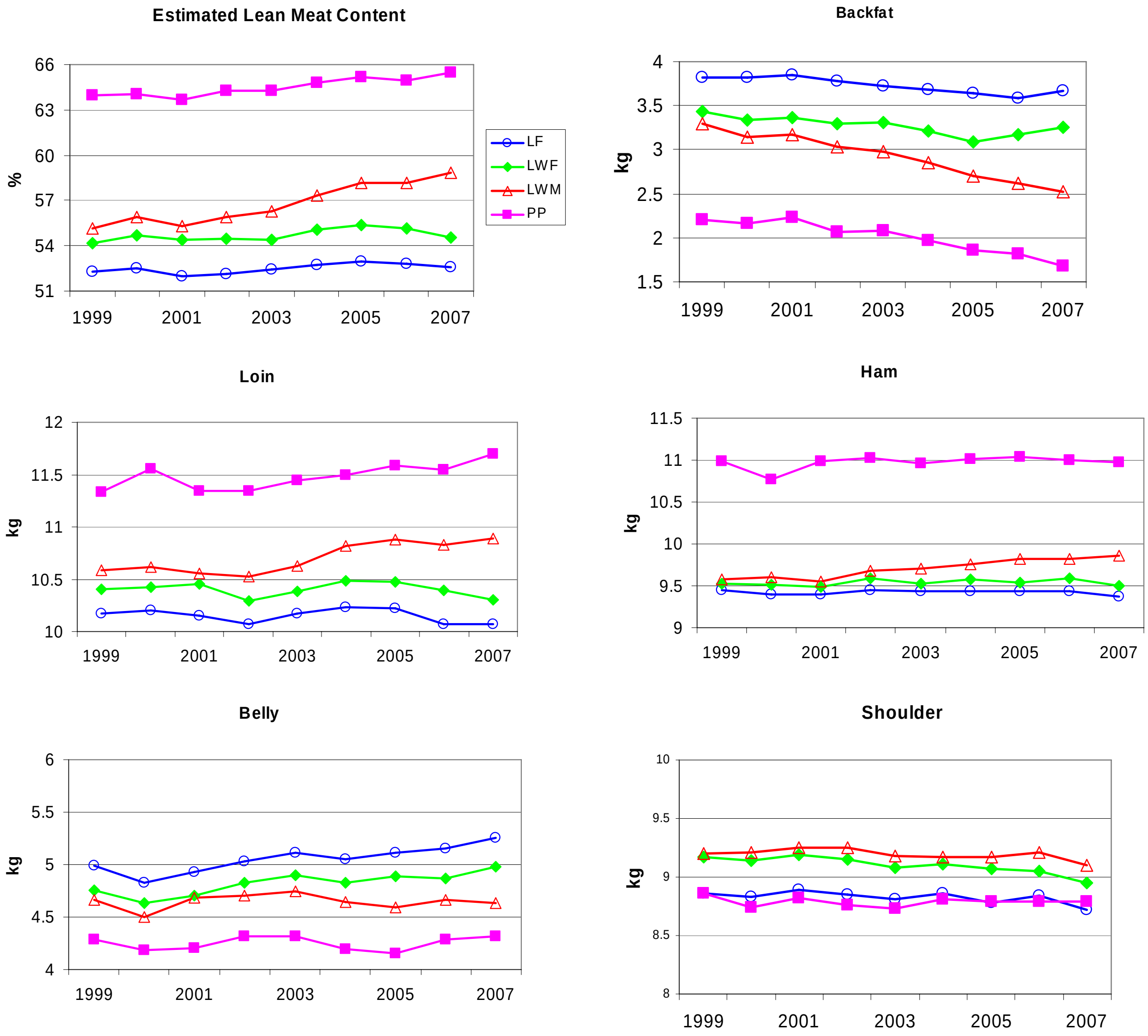

Figure 1. Phenotypic trends for estimated lean meat content and primal cuts

3. Influence of carcase weight on primal cuts and length

Allometric coefficients and relations are presented in Figure 2 and Table 3. Allometric coefficients show that belly and backfat weights exhibited the lowest increases with higher carcase weight. The highest weight increase was in the loin of the four breeds, followed by ham and then by shoulder weight increases.

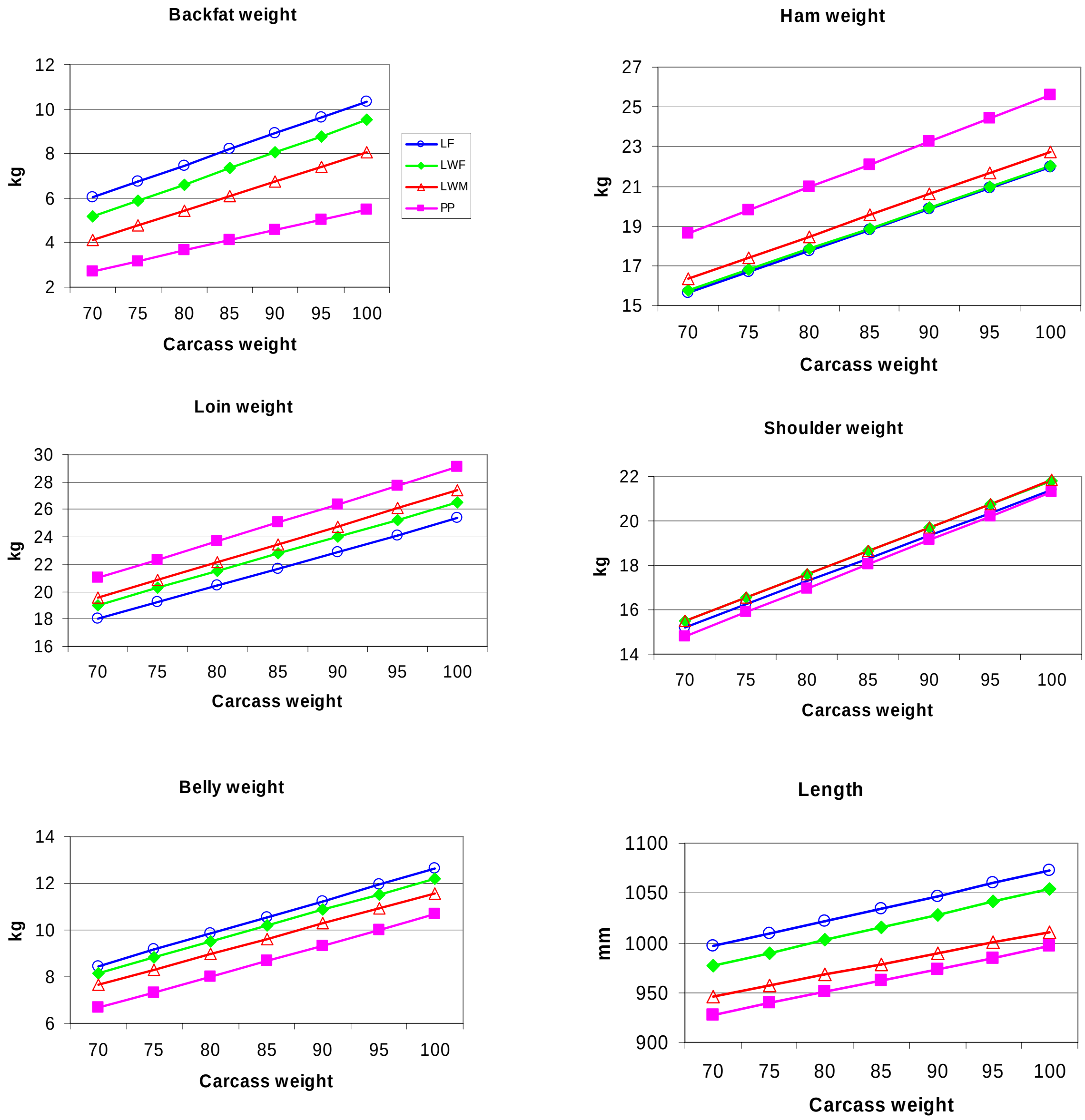

Figure 2. Estimated allometric relations for primal cuts weights and length against net carcase weight

Regression coefficients of Pietrain differed most for ham and backfat in comparison to the other three breeds. Per one kg of net carcase weight, backfat weight increased by 93 g in Pietrain versus 144 g increase in dam lines. Both sire lines also differed in the gain in ham and backfat weights with heavier carcases. The two Large White lines only differed in the increases in backfat weight and carcase length with higher carcase weights. Allometric relations for belly indicated no differences between breeds. Dam lines had larger regression coefficients for carcase length but coefficients did not differ from the Pietrain breed.

Table 3. Increase (in grams) of each main cut (both sides) and increase (in mm) in length of carcase per kg increase in carcase weight

	LF	LWF	LWM	PP
Ham	211[a]	209[a]	213[a]	232[b]
Loin	245[a]	249[ab]	260[bc]	270[c]
Belly	139[a]	135[a]	131[a]	133[a]
Shoulder	206[a]	209[ab]	210[ab]	217[b]
Backfat	144[a]	145[a]	131[b]	93[c]
Length	2.5[a]	2.6[a]	2.2[b]	2.3[ab]

LF: Landrace Français; LWF: Large White dam line; LWM: Large White sire line; PP: Pietrain
Increases with different superscripts differ significantly, $P < 0.05$.

Carcase weight explained around 63% of the variability of ham weight, 57% of the variability of loin weight and 48% of the variability of belly weight. However, differences were noted between breeds (Table 4).

Table 4. Proportion of variation for ham, loin and belly weight explained by the model

	LF	LWF	LWM	PP
Ham = NCW + e	0.6443	0.6419	0.6567	0.6045
Ham = NCW + F2 + e	0.6937	0.6891	0.7015	0.6240
Ham = NCW + M2 + e	0.6466	0.6492	0.6592	0.6096
Ham = NCW + F2 + M2 + e	0.6946	0.6921	0.7022	0.6292
Ham = NCW + length + e	0.6451	0.6479	0.6678	0.6241

	LF	LWF	LWM	PP
Loin = NCW + e	0.5443	0.5699	0.6627	0.5725
Loin = NCW + F2 + e	0.6353	0.6445	0.7477	0.5978
Loin = NCW + M2 + e	0.5673	0.5866	0.6872	0.5749
Loin = NCW + F2 + M2 + e	0.6450	0.6530	0.7548	0.5985
Loin = NCW + length + e	0.5699	0.5944	0.6785	0.5808

	LF	LWF	LWM	PP
Belly = NCW + e	0.4658	0.5001	0.4841	0.4518
Belly = NCW + F2 + e	0.4784	0.5102	0.5041	0.4751
Belly = NCW + M2 + e	0.4709	0.5055	0.4840	0.4585
Belly = NCW + F2 + M2 + e	0.4807	0.5144	0.5062	0.4816
Belly = NCW + length + e	0.4664	0.5020	0.4864	0.4519

F2: rib fat thickness; M2: rib muscle thickness; NCW: Net carcase weight; LF: Landrace Français; LWF: Large White dam line; LWM: Large White sire line; PP: Pietrain

In adding a measure of fat depth (F2, measured between the 3rd and 4th last rib vertebra), the proportion of variation explained by the model (coefficients of determination) increased by around 4% for ham and 8% for loin except for the Pietrain breed where the increase was only 2%. Adding fat depth to the model to predict the belly weight gave an increase in the coefficients of determination of only 1 to 2% across all breeds. A measure of muscle depth (M2, measured at the same place as the F2) did not improve the ability to predict ham and belly weights. For loins, information about muscle depth increased coefficients of determination by 2% in three breeds (LF, LWF, LWM) but did not improve prediction of loins in Pietrain pigs. However, muscle depth only explained an additional 1% of variation in loin in the three white breeds when fat depth was already fitted in the model. Carcase length increased coefficients of determination for loin weight by 1% (PP) to 3% (dam lines).

4. Variation of primal cuts at a fixed carcase weight and fat depth

Figure 3 shows the distribution of the weight of ham and loin for Landrace and Large White dam line breed for a fixed net carcase weight (80-81 kg for LF and 81-82 kg for LWF) and for a fixed fat depth (mean ± 1 mm, namely 17.5-19.5 for LF and 14.5 – 16.5 for LWF). These two sub-samples contained 145 Landrace carcases and 189 Large White dam line carcases. Under a payment system based on weight and fat depth only, these carcases would achieve a similar price due to the minimal variation in carcase weight and fat depth.

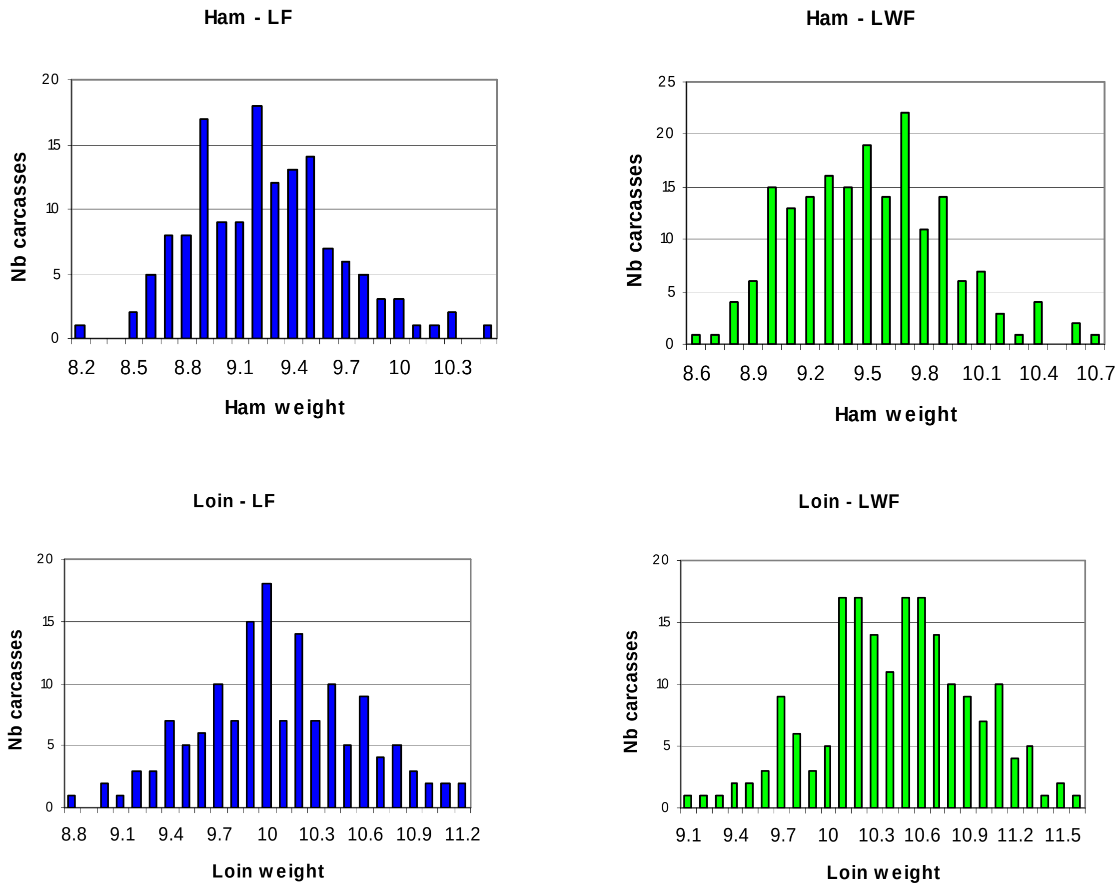

Figure 3. Distribution of ham and loin weight with fixed net carcase weight and fixed fat depth

Only results for dam lines are presented here, because more records were available for these breeds, but there was a variability of about 2 kg per cut regardless of breed. Thus, for constant weight carcase and fatness, there was variability in individual primal cuts.

5. Variation in saleable meat yield

Variability in saleable meat yield may be estimated by using the weights of individual cuts of the samples described above and multiplying them with the prices per kg of each primal cut given in Table 5. These prices may be at the producer, whole sale or retail level. Prices for producers' level as used by Green (2008) and wholesale/retail prices provided by Channon (personal communication, 2008) were used.

Table 5. Assumed producers' level and wholesale/retail prices for each primal cut (in A$ per kg)

	Loin	Ham	Belly	Shoulder
Producers' level	4.20	2.45	4.20	1.40
Wholesale/Retail prices	13.99	7.99	8.99	7.99

Table 6 gives the average carcase prices according to producers' level and wholesale/retail prices. Individual variability of primal cut weights at the same carcase weight and fat level can result in increased economic returns. Economic differences between the top 10% of carcases versus the average were about 3% of the average carcase price. At the producer level these differences equated to about A$ 7 per carcase in comparison to A$20 to A$23 per carcase at the wholesale/retail level.

Table 6. Number of carcases (N) in the sub-sample, average carcase price (in A$), standard deviation (SD) and economic gain for the top 10%

		N	Average carcase price (in A$)	SD	Economic gain per carcase due to choosing the top 10%	
					in A$	in %
Producers' level	**LF**	145	196	3.89	+7.1	+3.52 %
	LWF	189	200	3.85	+6.7	+3.23 %
Wholesale/	**LF**	145	658	11.94	+22.9	+3.24 %
Retail prices	**LWF**	189	674	11.94	+20.4	+2.93 %

Implications

The value of a pig carcase is determined by its weight, fatness level and muscularity but there are differences between genotypes in these characteristics. Differences in the carcase composition must be understood if pig management and efficiency of feed use are to be optimised, the required carcase specification produced, and environmental impact minimised.

For a long time, pig breeding programs focused mainly on the reduction of costs. Selection was aimed at increasing litter size, weight gain, decreasing backfat and improving feed conversion. Thus, lean tissue development in slaughter pigs has been emphasised over the past four decades in the swine industry.

The results of this study show that selection on backfat and muscle depth in addition to estimated lean meat content measured on siblings does not improve conformation in the whole carcase. As long as classification of carcases and payment system are based on measures of backfat and muscle thickness, pig breeding programs can maintain the estimated lean mean content as breeding goal. However, breeding goals are subject to change and may be directed much more towards retail carcase yield and meat quality because of increasing economic values for these traits. To solve these new challenges, using only backfat and muscle depth measurements will not be sufficient.

In Australia, selection for conformation is only based on backfat measurements. Genetic trends for backfat depth (http://npip.une.edu.au/) showed a plateau occurring since 2000 in Large White. To maintain selection on carcase conformation, it seems important to explore other selection criteria. Furthermore, the P2 fatness estimates carcase lean meat yield but does not give information on carcase qualities.

The development of new technologies allow estimates of the average lean content of the whole carcase and also estimates of the weight and quality of the valuable cuts. The technology for predicting ham and loin primal cut weights is developing (AutoVision and AutoFOM). In France, two abattoirs are actually equipped with AutoFOM. Because of these developments, the French pork industry is starting to use quality indicators in classification systems and is moving towards more refined value-based grading systems meeting the requirement of market segments. A similar trend is occurring in Australia. New technology is being developed that will describe carcase composition and conformation more accurately than current systems based on weight and fat depth only.

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