Selection for carcass composition and meat quality in the national breeding program in France

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Preamble

IFIP – the French institute for the pig and pork industry is an organisation to help and advise pig farmers and the pig industry. This national technical institute leads a) applied research and studies to produce knowledge and b) advisory, consultancy, extension, training to transfer knowledge. IFIP's mission is to support the professional organisations in the pork sector in order to foster modernisation, competitiveness and sustainable development.

IFIP is divided into four departments in order to cover the pork chain: pig farming techniques, genetic improvement, economics and meat quality (fresh and processed meats). The institute has a team of 100 employees including 80 scientists and technicians located at five sites, two of which are research stations.

The pig breeding department is made up of eight people and is involved in genetic evaluation (BLUP), coordination of the national data base and genetic evaluation system (with INRA – French national institute for agriculture research), monitoring of test stations, preservation of local breeds and genomic research.

Introduction

With 1.2 million parental sows producing 25 million slaughter pigs per year, France is one of the leading pig producers in the world. The content of lean meat is the most essential characteristic of pig carcasses and it forms the common basis for payment to pig producers and in markets after slaughter in all countries in the European Union.

Two purebred sire lines are bred in the national scheme: Large White sire line (LWM) and Pietrain (PP), with 460 LWM sows and 1230 PP sows under selection in 2007. Following the new grading criteria and payment grid defined in 2006, the trend is to increase the use of pure breeds selected as terminal purebred sire line boars at the expense of terminal hybrid boars. Indeed, in 2007, 69% of semen doses sold to production farms were from the Pietrain breed.

The aim of this article is to outline the existing selection program for carcass and meat quality which has been put into place in France, along with new strategies which will be developed in the short to medium term.

Payment system

The classification of pig carcasses in most European countries is based on linear measures of backfat and muscle thickness. Since December 2006, the lean meat content is defined as the lean meat percentage in the four main cuts and in France is called "TMP". It is predicted from one or two fat depths and one muscle depth. This equation is common to females and males as the sex effect has been considered negligible (Daumas, 2008). The measuring apparatus CGM (Captor Gras Maigre) is standardised on a national as well as a European Union level.

Weight payments apply to carcasses between 45 and 120 kg. Penalties apply for pigs outside the weight band of 80 to 102 kg and a bonus of 0.02 euros per kg (0.034 AUD) is applied between 85 and 97 kg. The base price is for a carcass with a lean meat content of 56%.

At the present time, meat quality is not remunerated but at medium / long term it will probably change. In fact, it is possible that a new payment or bonus system taking into account pH and carcass conformation (proportion of fat and muscle) may be applied, completing the system. Therefore, the French breeding program includes carcass composition and meat quality as breeding goal traits which is outlined below.

Control of performances: system based on on-farm testing combined with central testing

1. On-farm testing

Male and female animals tested on farm are bred under batch management, and performance tested in pens of 10 to 15 pigs under *ad libitum* feeding. Each batch is defined as a group with at least 18 animals of the same breed, sex and age (± 15 days). Six or three ultrasonic backfat measurements (right and left or only right) at 4 cm from the chordal spine are taken from boars and gilts weighing around 100 kg at the shoulder, mid-back and loin. The loin depth is measured by ultrasound in two points (right and left) between the third and fourth last ribs at 4 cm off the back midline. Animals are to be weighed at the same time when the ultrasonic measurements are taken. The weight is referred to as the probe weight and is used in the calculations for age to 100 kg (A100) as well as fat and lean at 100 kg (BF and LD). On a few on-farm pigs tested (less than 15%), ultimate pH is also recorded twenty hours post slaughter by technical advisers. Table 1 sums up performances measured in 2007 in the 22 purebred herds that take part in the national scheme.

Table 1. Number of records and mean performances for each trait measured on farm – Year 2007

Breed	Number of herds	Sex	Pigs tested	Off test weight (kg)	A100 (days)	BF (mm)	LD (mm)
LWM	8	Female	4278	98.2	147.8	10.0	55.2
		Male	2157	100.2	144.3	9.0	54.4
PP	14	Female	6465	99.5	154.4	7.7	65.9
		Male	7179	102.9	151.7	7.4	62.7

A100: age at 100 kg, BF: ultrasonic backfat thickness at 100 kg, LD: loin depth at 100 kg

Only the performances of sire lines – Large White sire line (LWM) and Pietrain (PP) – are presented here but selection emphasis on carcass composition and meat quality also exists in the dam lines of the national breeding program (Large White dam line and Landrace). Increased leanness may have its own consequences, especially on sow productivity. There are indications that leaner sows tend to have shorter longevity (López-Serrano *et al*., 2000).

2. Central test stations

Central pig testing stations have been used since 1986 for the combined evaluation of young boars selected for artificial insemination. In 1995, their use has been modified for health and sanitary reasons. Testing stations currently only receive siblings of on-farm tested animal candidates who will be slaughtered. The objective of obtaining data for these controls is to measure performances of pure breed animals in a controlled and non limiting environment.

Today, two central test stations receive piglets from breeding herds – the first one between 9 and 14 days (around 3.5 kg) and the other one at the age of four to five weeks (around 8 kg). The capacity of these two testing stations is about 2500 animals per year. Pigs are performance-tested in group pens of 12 animals and given *ad libitum* access to feed. Individual recording of feed intake occurs from approximately 30 kg to 110 kg bodyweight. Measurements at the slaughterhouse are: weight of the carcass and primal cuts, carcass length, ultimate pH at ~ 24 hours post-slaughter (pHu), coulor (L*), and water holding capacity (WHC). WHC scores, measured at the semi-membraneous muscle, are determined by the time required to wet completely 1 cm^2 of pH paper. The maximum score is 20 and corresponds to a dry meat.

Meat quality index (MQI) is calculated in accordance with the equation established in 1993 (ITP): MQI = -41 + 11.01 pHu + 0.105 WHC – 0.231 L*

Table 2. Means for production, body composition and meat quality traits measured on station adjusted for the effect of sex (females and barrows) – Year 2007

			LWM	PP
Pigs tested			198	331
Growth and feed intake performances		ADG 35-110 (g/d)	993	887
		FCR 35-110 kg (kg/kg)	2.59	2.50
		DFI 35-110 kg (kg/d)	2.57	2.04
Carcass quality	*Measured*	Dressing percentage (%)	79.9	82.8
		Ham weight (kg)	10.5	12.0
		Belly weight (kg)	5.0	4.9
		Shoulder weight (kg)	9.7	9.7
		Loin weight (kg)	11.6	12.9
		Back fat weight (kg)	2.9	2.2
	Predicted	Lean meat content = TMP (%)	60.5	64.6
		Estimated carcass lean meat content (%)	59.6	65.6
Meat quality		Ultimate pH	5.71	5.69
		Luminosity of *longissimus dorsi*	50.4	52.5
		Water holding capacity scores	10.3	2.5
		MQI	11.3	9.7

ADG: average daily gain, FCR: feed conversion ration, DFI: daily feed intake, MQI: meat quality index

The carcass lean meat content measured on slaughtered siblings and used for the genetic evaluation is not identical to the official grading criteria (lean meat content in Table 2). It is predicted in a different way which is more precise than the slaughterhouse's way, since it was developed specifically for these animals, in order to better show the differences between individuals.

Estimated carcass lean meat content = 25.08 – 1.23(% fat and rind weight above loin) + 0.87(%loin) + 0.73(%ham). Joint weights are expressed as a percentage of the weight of the half-carcass. This equation has been used since December 2006 in the centres for performance testing in the evaluation of slaughtered siblings. The residual mean squared error of prediction (RMSEP) was 1.34 while the error of prediction of TMP (lean meat content), the official grading criteria, was 1.84.

Since 1995, a continuous genetic evaluation system has been implemented in France to estimate breeding values of on-farm and station tested pigs for production traits using a multiple trait animal model. A monthly evaluation is performed using data for production traits. Data measured on farm and on station are summarised in Table 3. Within herd estimated breeding values are computed by combining results from the last national evaluation and the performance of on-farm tested young pigs.

Table 3. Performances recorded on farm and for station tested pigs

Traits	on farm	on testing stations
Growth	A100	ADG 35-110 kg
Feed intake		FCR 35-110 kg
		DFI 35-110 kg
Carcass quality	BF	Dressing percentage
	LD	Estimated carcass lean meat content
Meat quality	Ultimate pH24	MQI (ultimate pH24, colour and water holding capacity)

For abbreviations see notes below Tables 1 and 2.

Breeding goals and genetic improvement for carcass and meat quality

The main breeding goals for sire lines concentrate on improving growth performances (growth rate, feed conversion ratio), carcass and meat quality (carcass composition, insensitivity to stress, meat quality ...). The breeding goal for a sire line is therefore a linear combination of ADG, FCR, estimated carcass lean meat content, dressing percentage and meat quality index. In 1994, at the time of the installation of BLUP in France, economic weights have been determined with economic models developed by Ducos (1994), except for the value for meat quality which has been fixed in order to keep the level of meat quality constant. Since then, weights of breeding goal traits (Table 4 & Figure 1) are determined by a desired gain approach with the OPTIPIG software developed by Maignel *et al*. (1997). OPTIPIG is a simulation program designed to model swine schemes. It is based on a deterministic model using gene-flow theory.

Table 4. Weights of breeding goal traits since 2002

Traits	ADG	FCR	Dressing percentage	Estimated lean meat content	MQI
LWM	0.243	-109	13	12	25
PP	0.243	-109	13	4	13

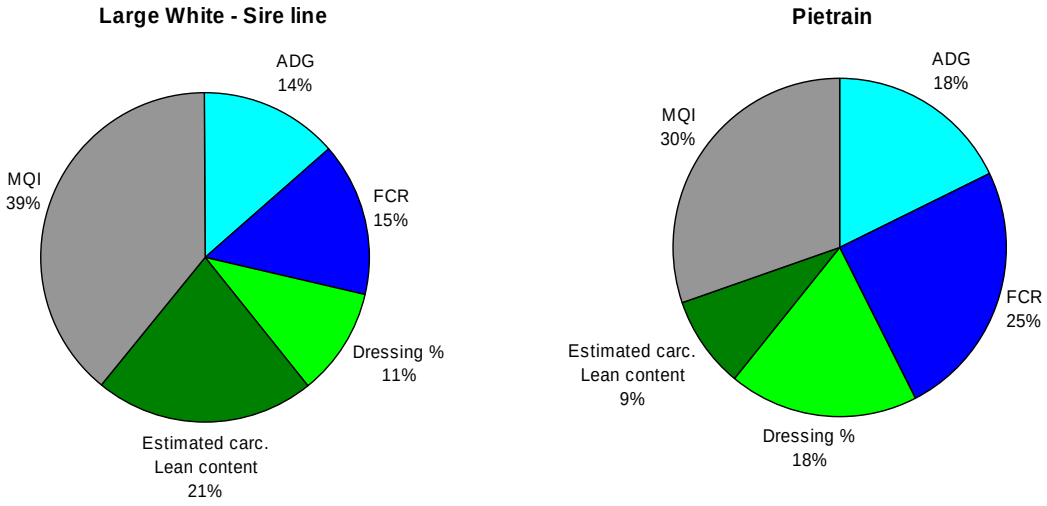

Figure 1. Relative weights of the breeding goal traits for purebred sire lines (in fraction of unit phenotypic standard deviation)

Genetic trends are evaluated using data from participating breeders over a 5-year period from 2002-2007. The PEST genetic evaluation software is used to produce breeding value estimates. Genetic trends are estimated as the average breeding value for all animals born during a specific year. Genetic trends are presented in the two following graphs for carcass lean meat content and meat quality index.

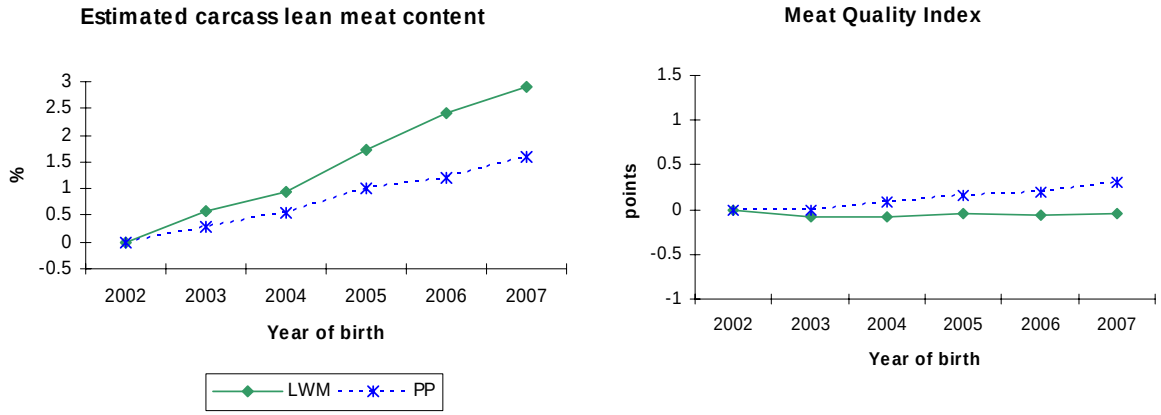

Figure 2. Genetic improvement trends

A genetic improvement of 3% in carcass lean meat content has been achieved in LWM from 2002 to 2007, or 0.6% per year. The progress in the Pietrain breed is about half this rate because of lower variability and lower weight in the breeding goal. As expected, the genetic trend for meat quality is zero to slightly positive.

Perspectives

1. Short term

Even if no direct payments are currently received for meat quality, it seems to be important to continue doing research on this topic. The increasing use of the Pietrain breed as a terminal sire obliges selection to improve drip loss for fresh meat. A recent study managed in collaboration with the Canadian Centre for Swine Improvement (Mérour *et al*., 2007) has shown that scoring water holding capacity is not the best measurement method to predict drip loss. This method was proposed at the beginning of the 1980s to estimate cooking-yield of cured-cooked ham. Actually, on Pietrain animals tested in stations, a new measurement is carried out: drip loss measured in a commercial tray. When enough data are collected, genetic parameters will be estimated and a new index of meat quality including drip loss of fresh meat will be proposed to the French breeding companies linked to the national program.

Furthermore, a genetic evaluation taking into account individual genotypes for Porcine Stress Syndrome (PSS) will be developed soon. The genotype for all Pietrain animals is deducted from parents or it is determined from DNA extracted from biopsy.

A new interest for computed tomography (CT) in pig grading arose concurrently with the European research project EUPIGCLASS (www.eupigclass.net), aiming to increase the harmonisation in pig classification. The reference lean meat percentage, needed to calibrate the classification methods, is obtained by manual dissection. As the dissection is laborious, costly and difficult to standardise, the EUPIGCLASS consortium has studied the potential of CT and MRI to replace dissection. This consortium concluded that both methods are relevant to replace dissection. Subsequently, the main countries in pig production (Germany, Spain, France and Denmark) have bought a CT, essentially because this is less expensive than MRI. According to Kolstad (2001), CT could be included in the breeding evaluation of sire lines. This will be a more efficient way of improving efficiency as well as quality traits related to fat distribution.

In February 2008, the French institute acquired a mobile CT scanner on a purpose-build truck. As a first step, this new equipment will be used to obtain data for applying multivariate modeling methods towards predicting the lean meat content. Secondly, the CT scanner will be used for studies in feeding or breeding. A project which aims at trying to find new breeding traits in sire lines (conformation) using CT scanning on carcasses will be realised at the end of 2009. In the future, scanning of live animals will be conducted.

2. Medium term

Sequencing of the pig genome is still in progress. To date, sequencing is at 71% sequence coverage and should be finished in 2009. New SNP (Single Nucleotid polymorphism) have been identified (deduced from sequence data) and a Pig SNP chip (produced by Illumina) will soon be available. It will contain 60 000 SNP. It will be useful in association studies which compare performances for the different genotypes at the 60 000 markers. Because of the huge number of markers, association studies potentially allow (in one step) a fine localisation of genes: this is very powerful in other species (dog for example) and we hope it will also be promising for pigs.

Genomic selection is the prediction of the breeding value of an animal only based on its genome which means using genotypes for a large number of markers (several thousands). This method starts to be used in cattle breeding (but only to augment traditional breeding) although it still needs methodological developments. So far it has not been proven that it will be efficient and economically acceptable in pigs.

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