Implementation of selection for carcass (and meat) quality in a pig breeding program in the Netherlands

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1. Introduction

In North America and in Western Europe the valuation of pork is changing from input driven towards output directed. It is changing from selling the products of slaughtered pigs towards producing the pigs for which a clear market exists. Two discussions are underway; one is about specifications and value of pork products and the other one on classification systems. These classification systems try to estimate the quantity and quality of the products in the earliest possible stage, at the very moment the pig is killed. Known and used systems are Hennessey Grading Probe (HGP) and AutoFOM.
Value of products depends on market and season. Known markets are bacon, retail, industry and cured hams. Product specifications for these markets differ (quite a bit.) Combining the specifications is difficult. The ideal pig seems to need a, not too lean, ham of a pig of 160 kg, combined with the middle of a 110 kg pig and a very heavy lean shoulder. Sire line differentiation will be necessary and from there within line improvement.
In the current article we would like to present some of the implementations and considerations for a pig breeding program for carcass quality.

2. Payment systems

In the old days, pigs were sold based on live weight. Some changes occurred when weight basis changed to carcass weight. Marked improvements were premiums on quality (read: low backfat). At present, the Hennessey Grading Probe (HGP) or Fat-O-Meter (FOM) is used in many markets to estimate lean content in the whole carcass.
A, relatively, new development is the more direct link between commercial cuts leaving the meat plant and the payment to the farmer. This is facilitated by the use of classification systems which estimate not only the average lean content, but also the weight and quality of the valuable cuts, e.g. AutoFOM, which estimates the muscle weight of the shoulder, the ham, the loin and the belly. Remarkable is, that German meat plants use non linear payment systems to valuate these cuts. The price per kg loin increases if weight exceeds a certain threshold. Similarly the price per kg loin increases with weight up to a specific optimum weight range and decreases afterwards (see Figure 1). Market (bacon, retail, and industry), competition, season and changes in consumer appreciation will change thresholds and optimum ranges over time.

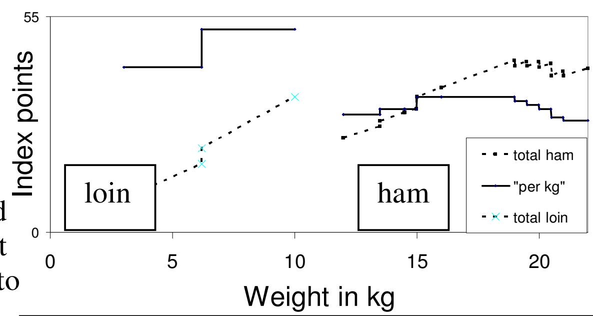


Fig. 1: Price per kg of deboned loin (left) and kg of deboned ham (right). And total value (weight*price) of deboned loin, resp. ham.

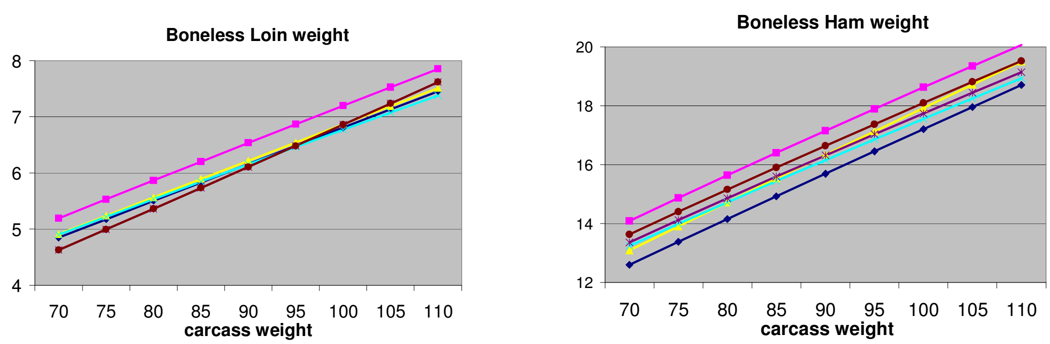
However, the trend will remain the same; more and more, farmers will be paid on the commercial cuts taken out of their pigs instead of on the average lean content.

3. Dissection

Reference for decisions should be real saleable meat. Therefore, a large number of carcasses have been dissected according to commercial procedure. Carcass is divided in shoulder, middle and ham, and middle in loin and belly. These four parts are referred to as primals. Loin and ham primals are then divided in subprimals, that is, deboned and fat trimmed. The subprimal for loin is the loin string, for ham it is 4 or 5 ham muscle groups. Separation of middle and ham is different in North America, than it is in Europe. The loin primal is bigger in North America and therefore, the ham smaller.
In our current data set (per July 1st 2004) we have 2555 records of crossbred pigs of a single experiment in the United States, 2400 records from pure line animals in Canada and 3850 records of crossbred pigs in the Netherlands.

4. Differences between sire lines

On a 180 sow experimental farm 4 sire lines were compared on 2 commercial sow-crosses in a three week batch farrowing system. Offspring were dissected and allometric relations were estimated between boneless weights of loin and ham and carcass weight. Significant and relevant differences between sire lines exist. In Figures 2a and 2b the upper lines are of offspring of a RYR-negative Pietrain line. The other sire lines do not differ significantly for loin weight, but do for ham weight.



Figures 2a and 2b. Estimated allometric relations for boneless yields against carcass weight for offspring of different sire lines in a commercial finishing situation.

5. Differences within lines

5.1. Genetic variation

The USA experimental dataset and the Canadian dataset were used to estimate genetic parameters for a synthetic line in a crossbred and a purebred situation, respectively with the help of ASReml (Gilmour *et al.*, 2002). Performance levels and heritabilities are given in Tables 1a and 1b. Heritabilities and estimated genetic variance are very similar for both boneless ham and boneless loin weights for the crossbred and purebred populations. Average heritability is 0.42, which is promising for selection.

Table 1a. Means, common environment, heritability and genetic variance estimates for a sire line in a *pure*bred situation, based on 1800 observations.

	mean	c^2	h^2	var(add)	σ_a
US backfat	14.87	0.14	0.51	2.830	1.68
US loin depth	62.23	0.03	0.33	3.975	1.99
boneless loin, kg	7.44	0.04	0.41	0.043	0.21
boneless ham, kg	11.36	0.00	0.43	0.114	0.34

Table 1b. Means, common environment, heritability and genetic variance estimates for a sire line in a *cross*bred situation, based on 1050 observations.

	Mean	c^2	h^2	var(add)	σ_a
HGP backfat	25.12	0.15	0.45	11.220	3.35
HGP loin depth	59.29	0.04	0.13	8.880	2.98
boneless loin, kg	6.58	0.18	0.51	0.038	0.20
boneless ham, kg	10.48	0.13	0.39	0.056	0.24

5.2. Correlated traits

If a breeding goal includes boneless weights of ham and loin then in selection program terms these same traits should be measured and put in the index. Dissecting carcasses has two major drawbacks, however: cost and loss of the breeding animal.
Over the years, ultrasonic backfat has proven to be a very good predictor for total lean in the carcass. The ultrasonic technique has been improved to accommodate the measurement of loin depth in live animals. Correlations between the two measurements and the boneless weights are given in Tables 2a and 2b.

Table 2a. Genetic and phenotypic correlations between ultrasonic measurements on live animals and their dissected boneless weights estimated in a pure line population.

Pure Line Genetic	"Live" Loin depth	"Live" Back fat	Pure Line Phenotypic	"Live" Loin depth	"Live" Back fat
boneless loin	0.88	-0.49	boneless loin	0.33	-0.20
boneless ham	0.68	-0.60	boneless ham	0.25	-0.38

Table 2b. Genetic and phenotypic correlations between ultrasonic measurements on live animals and their dissected boneless weights estimated in a crossbred population.

Crossbred genetic	HGP Loin depth	HGP Back fat	Crossbred Phenotypic	HGP Loin depth	HGP Back fat
boneless loin	0.65	-0.60	boneless loin	0.27	-0.45
boneless ham	0.34	-0.86	boneless ham	0.13	-0.46

6. Expected genetic trend

The above mentioned parameters were combined in a simulation of a breeding program Selaction (Rutten *et al.,* 2002) with a purebred population of 400 sows and 30 boars, 5000 animals performance tested on backfat and loin depth, 800 animals dissected and the availability of the HGP data of 5000 crossbred animals, sired by the same 30 nucleus boars. Breeding goal: maximisation of boneless loin and ham weights.

Seven strategies were analysed.

1. Simple: only measuring ultrasonic backfat;
2. Simple plus: measuring backfat and loin depth;
3. Dissection: backfat plus dissection of 1 animal per litter for the whole population;
4. Crossbred information: backfat on selection candidates plus half-sib crossbred data;
5. Maximal: backfat, loin depth, dissection and HGP information;
6. Simple boars plus: backfat on all selection candidates and loin depth only on boars;
7. Optimal: backfat and loin depth on boars and half of the dissections.

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Table 3

Efficiency of the scenarios

Scenario	ΔG meat in g	Relative
1	308	100
2	488	164
3	416	137
4	400	131
5	513	171
6	462	155
7	467	156

Measurement of only backfat will increase the amount of boneless ham and loin weights with around 308 gram per carcass per year. Adding measurement of loin depth will create an extra 180 gram per year, which is, a 64 % increase. The maximum scenario (scenario 5) is 171 % of the basic situation. A simplification and considerable cost-reduction is measuring loin depth on boars only. Loss in genetic trend is then 9 % (from 164 to 155). Adding half of the dissections (scenario 7) only yields a bit extra.

7. Discussion

Market approach moves from total lean content in the carcass towards a commercial cut approach. Differences in boneless loin and boneless ham weights exist between sire lines. (Some) current markets prefer an optimum weight for ham and a maximum for loin. It might be profitable for a breeding organisation to differentiate between sire lines. This article does not answer the question whether it is possible to change loin weight independent of ham weight. It does show, however, that both boneless weights are very heritable and subject to genetic change. When measuring both backfat and loin depth, selection results in not only less fat, but also more 'real' muscle.

Simulated selection as presented here is a simplification of the real selection since that includes more traits than only boneless weights.

The actual genetic trends simulated were twice the size of the ones presented. The simulated breeding program was very straightforward and without problems. We took a 'fudge factor' of 2 to take into account: leg problems, bad semen, uneven animal flow, human errors etc.

Economic values were applied linearly, while for a plateau approach it should be used in a non linear way. (population average close to maximum of the optimum weight yield, the economic value will be much lower than if below the lower weight of the optimum range).

8. References

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Rutten, M.J.M, P. Bijma, J. A. Woolliams, and J. A. M. van Arendonk SelAction: Software to Predict Selection Response and Rate of Inbreeding in Livestock Breeding Programs J. Hered., 2002; 93(6): 456 - 458.

9. Acknowledgements

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