Improving meat quality advantages by genetic selection

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Pork meat comes from the pigs that result from using sire line genetics on a commercial crossbred sow. In the global pig industry indoor pig production systems favour a Large White x Landrace sow.

The sows have been bred for their mothering abilities, prolificacy, longevity and the production system in which they are managed. Sire animals are selected based on what is desired from the final commercial progeny, for example large loin eye area, large ham muscle or further processing ability.

The inclusion of at least 50% Duroc genetics, while having no deleterious effects on daily live weight gain and typically only marginally worse lean tissue conversion ratio results in significantly darker meat, firmer fat and increased marbling. The MLC (1992) Blueprint recommends a 50-75% Duroc inclusion for improved pork tenderness and juiciness.

However, other commercially used sire lines are known to have meat quality advantages. Pig producers aim to produce slaughter animals that have an efficient conversion of feed into good quality lean meat, since consumers demand lean meat at the lowest possible cost.

Commercially the halothane gene is of interest since its presence is associated with an increased content of lean meat in the carcase.

However, the gene is also linked to porcine stress syndrome in pigs (PSS), which results in increased levels of PSE (Pale, Soft and Exudative) in meat. Different sire lines have been bred and improved by different genetics companies to meet the specific remit of processors and retailers. The sire lines need to be halothane negative to prevent PSE meat.

However, consumer acceptability is only recently becoming a key factor of influence when selecting sire lines for commercial progeny.

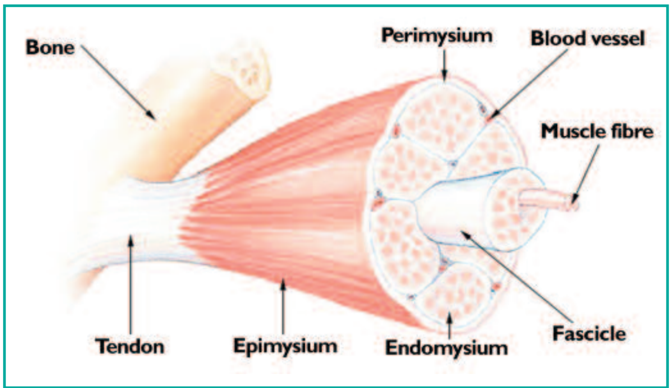

Fig. 1. Structure of a skeletal muscle.

Selecting the dam line

The choice of dam line is often mostly affected by the production system to be used. However, it should be considered that some dam lines contain Duroc in their genetics that will improve the eating quality of the offspring if used in conjunction with a sire line to raise the Duroc percentage in the progeny above 50%.

However, if both sire and dam contain genetics for colour the progeny are likely to also show colour as shown in Table 1. The allele responsible for the red coat colour in Durocs is recessive to the allele for white coat colour and if the Duroc is restricted to only one side of the pedigree and crossed with white breeds few problems with deep seated hairs are likely. When choosing the dam line it is important to consider that consistency in the birth weight of piglets and length of gestation will affect final meat quality of the slaughter animal.

Both muscle and intramuscular fat development potential are determined prior to farrowing during the foetal and neonatal stages. Both are formed from the same ancestor cells (mesenchymal cells), which are abundant in the skeletal muscle at early development stages but numbers diminish as the animals get older. Most of the mesenchymal cells will form muscle cells, however, some will differentiate into fat cells (adipocytes).

It is the number and size of the myofibres in muscle that are the main determinants of muscle mass and both the number and size are established following a complex sequence of pre- and postnatal events. Studies of cattle have shown that the majority of the muscle fibres are formed prior to birth, confirming the importance of foetal development to meat quality. Intramuscular fat (marbling fat) is created by the enlargement of existing adipocytes (hypertrophy) and by increasing the number of adipocyte cells (hyperplasia) the initial number of adipocyte cells will therefore influence the level or marbling achievable.

Table 1. Incidence of colour based on parenting. Designed and used by JSR Genetics Ltd based on genetic marker technology.

Gilts		Hampshire (%)	Pietrain (%)	Duroc (%)	White Pietrain (%)	Large White (%)
White parent	Spots/patches	10	1	10	0.3	0.3
	Full colour	0	0	0	0	0
12% White Duroc	Spots/patches	10	1.6	10	0.4	0.4
	Full colour	0.6 white belt	0.6	0.6	<0.1	<0.1
25% Red Duroc	Spots/patches	7.5	2.4	7.5	1.4	1.4
	Full colour	25 white belt	25	25	1.3	1.3
50% Red Duroc	Spots/patches	5	2.8	5	3.4	3.4
	Full colour	50 white belt	50.0	50	2.5	2.5

Selecting the sire line

Sire line is often chosen to maximise hybrid vigour, disease resistance and conformation. However, a sire line boar with good conformation does not mean the progeny will have good meat eating quality. Carcase quality and meat quality are only weakly related, if at all and several studies in sheep population have demonstrated that conformation is often highly correlated with carcase fat levels. There are only two sire line breeds (Duroc and Hampshire) that have been proven to produce consistently high eating quality meat. However, when using good eating quality sire lines the genetics of these lines also need to be considered.

Duroc sire lines

To ensure worthwhile improvement in eating quality it has been recom-

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	0% Duroc	25% Duroc	50% Duroc	s.e.
Killing out (%)	75.5^a	75.8^b	76.1^c	0.0014^{**}
P2 (mm)	10.6^a	11.6^b	12.7^c	0.14^{**}

a,b,c means values in a row with different superscripts differ significantly (P<0.05)

Table 2. Effects of inclusion level of Duroc (Blanchard et al. 1999).

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mended that there is at least a 50% inclusion of Duroc in the slaughter generation.

There is no significant difference in daily live weight gain to white sire line genotypes, whilst the lean tissue and subcutaneous fat growth rates are higher (P<0.05) in 50% Duroc progeny.

In addition, as the inclusion level of Duroc increases the killing out percentage was positively affected and the P2 fat thickness also increased (See Table 2). In addition, 50% Duroc animals have higher fat firmness scores and higher subcutaneous backfat levels compared to the 25% and 0% inclusion animals.

As the percentage content of Duroc increases from 0% to 25% and 50% the Longissimus Dorsi (LD) becomes significantly darker (P<0.05).

The darker colour of the muscle is related to an increased muscle haem (red pigment) concentration for the Duroc suggesting more red oxidative fibres, which gives the meat this darker colour.

There is no significant difference in drip loss, rind side blemish, or deep-seated hairs between different percentages of Duroc. D'Souza and Mullan (2002) reported higher pH_{24} in a 50% Duroc line compared with a <25% Duroc line, although WHC was lower in the former.

Hampshire sire lines

The Hampshire breed is a known carrier of the Rendement Napole (RN^-) gene and as a result slaughter progeny carrying the gene are associated with acid meat.

Carriers of the RN^- gene have a high glycogen content in the muscles which makes a lower ultimate pH possible. A low ultimate pH in meat is also associated with a reduced water holding capacity. However, the increased rate of pH fall has been shown to have positive effects on tenderness by improving the proteolytic action within the muscle. As a result the meat is more tender then that from non-carriers, making it more acceptable to the consumer.

Moreover, the Hampshire breed is used in the production of slaughter progeny because it has a superior performance on farm, with a higher daily gain and produces a carcase with a higher lean meat content and a larger proportion ham. A study by Enfält et al (1997) also showed that RN^- carriers have a larger ham then non-carriers. In addition, muscles from the Hampshire breed have been shown to have a darker redder colour, which is due to having higher concentrations of the myoglobin pigment in muscle.

Genetics affecting quality

The halothane gene (nn) is also known as the porcine stress syndrome gene (PSS). It is triggered by stress and causes malignant hyperthermia, which is associated with the development of PSE meat. PSE meat is caused by extensive protein denaturation that results from low pH and high temperature, in combination, shortly after post-mortem (usually 45 minutes post mortem).

Carriers of the halothane gene, both homozygous and heterozygous, are highly susceptible to stress. Even when careful handling has been used, pre-slaughter stress is often sufficient to cause a high rate of post-mortem glycolysis in pigs resulting in low pH_{45} values in combination with higher temperatures leading to protein denaturation and PSE meat. The effect of stress is more severe in homozygous animals.

When present in pigs as either a homozygous or heterozygous form the halothane gene results in the animals having higher carcase yields and higher lean meat percentages. The benefits the halothane gene has on the carcase characteristics of the pigs are, however, cancelled by the negative effect on both the colour and water holding capacity (WHC) of the meat.

As discussed by Rosenvold et al, (2003) the technological yield is reduced by 2-3% in meat from carriers of the halothane gene compared with non-carriers.

The RN^- gene

The Rendement Napole gene (RN^-) is associated with a reduced technological yield, due to an increase in drip loss. The RN^- gene is only found in Hampshire pigs and is thought to cause high muscle glycogen stores and an extended pH decline post-mortem.

The glycogen content increase is thought to be especially prevalent in muscles with high levels of white glycolytic fibres with redder muscles being little affected.

The presence of the RN^- gene results in a low pH_u, it does not affect the pH_{45} of the meat. The low pH_u that results has caused meat from RN^- carriers to be known as acid meat and is associated with meat being lighter (higher reflectance) and having a greater drip and cooking loss due to reduced water holding capacity.

This is because while the presence of the halothane gene has a dramatic effect on WHC, the RN^- gene only increases drip loss by approximately 1%. In contrast, the technological yield is reduced by 5-6% although Warriss (2000) found an 8% technological decrease. However, the RN^- gene is also known to have positive effects on the quality of meat. Studies have shown that pork from the RN^- genotype is redder then from non-carriers and that the meat from RN^- pigs is of a superior colour during display in air.

Major ham muscles are larger in RN^- carriers then non-carriers and as previously discussed the meat exhibits greater tenderness due to the increased rate of pH fall.

Improved meat flavour

Meat flavour from RN^- animals is also improved when compared to non-carriers. In addition, the muscles contain higher levels of marbling fat which has positive effects on the consumer acceptability of the meat.

Not including the RN^- or halothane genes, attributes that are known to affect the quality of pork show a low to moderate (0.15-0.30) heritability, with the exception of the inheritance of intramuscular fat content which has a heritability of 0.40-0.50. Heritability is the proportion of variation seen that can be explained by the genetics of the animals.

Although the heritability of intramuscular fat percentage and fat tissue is high (0.50 and 0.69, respectively) the genetic correlation between them is very low (0.11).

This suggests that selection for high intramuscular fat in lean carcases should be possible. The heritability of pH_{24} has been shown to be approximately 0.21 (range of 0.07-0.39). However, as discussed by Rosenvold et al, (2003) it has been shown that pH_{24} in populations free of the halothane gene and the RN^- gene may not be the ideal indicator of meat quality.

As discussed the genetics of both the sire and dam can have a huge effect on the final quality of the meat. The genetics of the commercial progeny are the starting point of meat quality. ■

References are available from the author on request

Book Review

Pathogenesis of Bacterial Infections in Animals

The fourth edition of Pathogenesis of Bacterial Infections in Animals reviews the latest developments in our understanding of the mechanisms of virulence of the major bacterial pathogens affecting animals. In this edition fresh emphasis is given to bacterial evasion of the immune system, overarching themes in pathogenesis and the contributions of pathogenomics.

As in previous editions the book basically focuses on giving an overview of the pathogenesis of important bacterial diseases including relevant events that occur in the herd and its environment with an in depth analysis of happenings at the cellular level.

After considering underlying principles the book goes on to consider their application to bacteria such as staphylococcus, mycobacterium, listeria, clostridia, salmonella, bordetella, brucella, pasteurella, mannheimia, campylobacter, Lawsonia intracellularis, Leptospira, mycoplasma and chlamydia.

This compact but detailed text has contributions from 74 international experts and includes a colour plate section.

This book is a valuable reference tome for veterinarians, microbiologists and pathologists.

Editors: Carlton L. Gyles, John F. Prescott, J. Glenn Songer and Charles O. Thoen
Publishers: Wiley-Blackwell, A. John Wiley & Sons Inc