TECHNICAL NOTE

LowInputBreeds

Challenges and solutions to problems in pork quality

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About

Meat quality is not particularly well served by modern pig breeding programs. This has led to failures in meat quality, which could endanger pork's image and economic success of pig production. There is hope these underlying problems in meat quality can be resolved if there is an economic motivation for producers, induced by consumers.

This technical note gives an introduction to pork quality and outlines solutions to improve it.

Background

Meat quality is a highly heterogeneous subject and can be considered as two complexes: "product quality" and "process quality" (see figure 1 on page 2).

Product quality subsumes characteristics directly measurable in meat like

(i) sensory (e.g. tenderness, juiciness, flavour)

(ii) chemical/physical (e.g. intramuscular fat content, fatty acid pattern, pH-value, electrical conductivity),

(iii) hygienic/toxicological (e.g. germ status, residue load), and

(iv) technological (e.g. processing suitability, fat consistency) properties.

Process quality relates to the production process throughout the supply chain, with

(i) characteristics directly influencing various properties of the product quality (e.g. choice of breed; feeding intensity; transport, slaughtering, chilling & storage conditions), and

(ii) intangible properties inherent in its production (e.g. eco-friendly production, animal-friendly housing, defined origin of meat, certified quality management systems).

Picture 1: Today price, size, and fat are generally the most important buying criteria for pork. (Photo: F. Weißmann, TI)

These quality characteristics play a more or less important or unimportant role in a more or less conscious or unconscious reflection concerning the consumers' purchase decision for or against pork.

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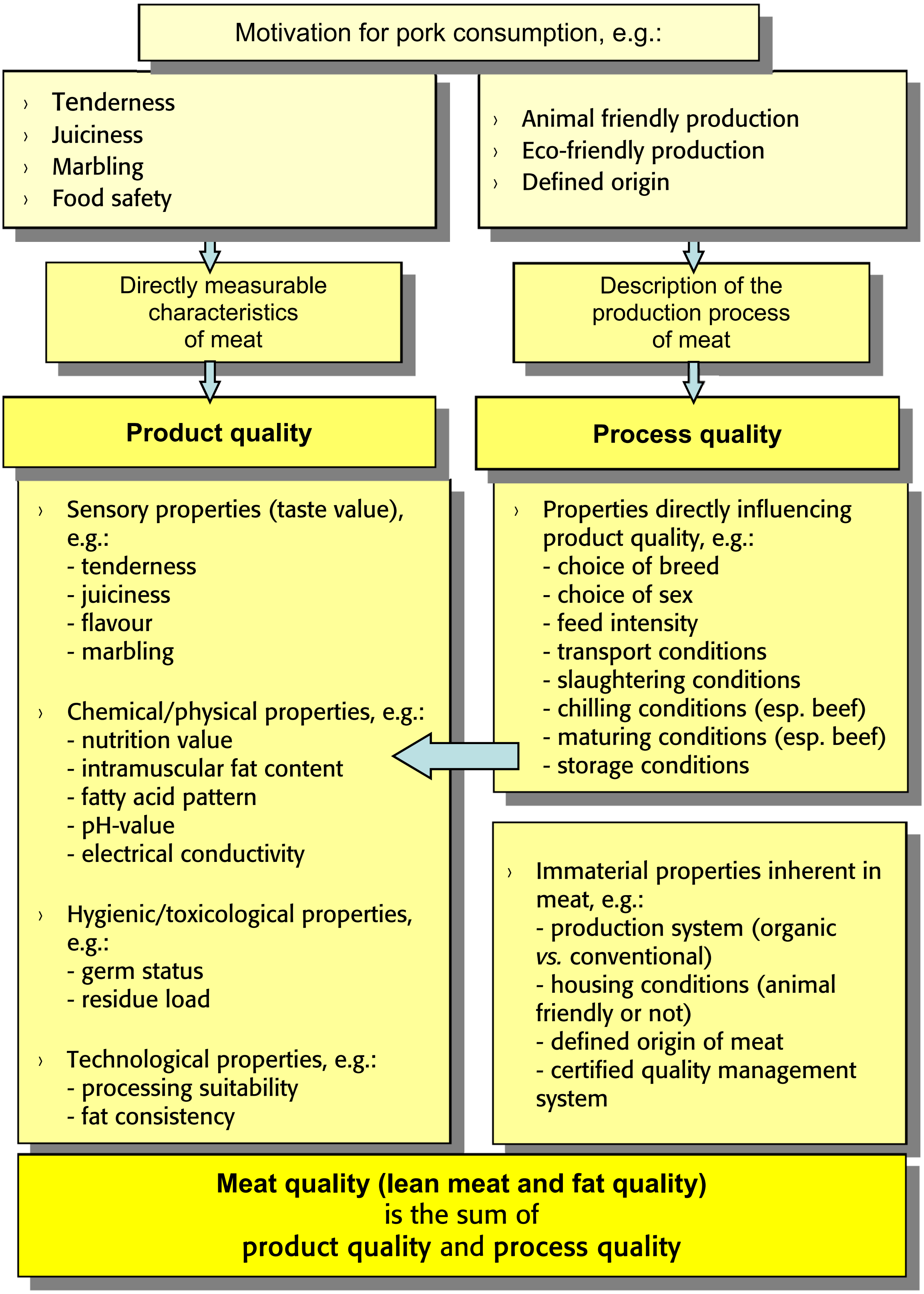

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Figure 1. What is meat quality?

Value creation in pork production today is predominantly based on improved carcass quality (lean meat content, amount of valuable cuts) and – additionally on the farm level – on improved animal performance (daily weight gain, feed conversion). Meat quality, in the above sense, only plays a role in the claim for (i) a lack of hygienic & toxicological complaints,

(i) a lack of hygienic & toxicological complaints,

(ii) a certain consideration of processing suitability (i.e. firm fat consistency), and

(iii) the absence of PSE-manifestation – a serious sensory meat quality defect in the form of pale, soft, and exudative pork leading to missing taste value and processing suitability.

The almost unrestrained increase in carcass lean meat content, induced the following problems in pork quality:

(i) PSE-syndrome,

(ii) inferior fat consistency, and

(iii) sensory meat quality deficits in terms of decreased intramuscular fat content and of minor water binding capacity.

These quality problems will be explained and solutions will be outlined.

PSE-syndrome

Genetically determined susceptibility to PSE

Unchecked breeding for high body protein synthesis has selected animals with muscle cell types associated with a severe sensory meat quality defect. This is the so-called genetically induced malignant hyperthermia syndrome (MHS) in swine, also known as porcine stress syndrome (PSS). Affected pigs show increased stress susceptibility and the PSE meat aberrance (pale, soft, exudative). After slaughter, high levels of glycogen stored in the muscles are converted to lactic acid, dropping the pH too rapidly, resulting in changes in muscle proteins and ruptures of cell membranes. As a result, meat becomes a pale colour, leakage of intracellular liquid causes an exudative or wet surface and soft consistency. Subsequent processing results in further leakage of meat juice causing stringy and strawy pork. PSE-pork not only causes these taste problems, but also severe losses in usability.

Hence, PSE-problems need to be reversed. This succeeded to a large extent by a breeding approach to eliminating the MHS-gene resulting in animals of homozygous negative MHS-gene status, so-called nn-type; animals homozygous positive to MHS are known as pp-type, showing the condition whilst heterozygous np-types do not exhibit but transmit MHS. Unfortunately, nn-pigs tend to have lower lean meat deposition associated with lower value carcasses and selection within these lines for higher lean meat yields increases PSE-susceptibility.

Two technologies to exclude PSE-pork

Therefore identifying PSE-pork after slaughter is an indispensable tool to exclude it from the supply chain. Two technologies are used in abattoirs: measuring pH and/or electrical conductivity (EC) of the muscle. Both systems are able to deliver threshold values for PSE-exclusion depending on an exact carcass location and time after slaughter. The two common locations are (i) loin (*Musculus longissimus dorsi*) between 12th and 13th rib of the split line of the carcass and (ii) topside (*Musculus semimembranosus*) within ham.

Picture 2: Pistol for measurement of the electrical conductivity of the meat. **(Photo: F. Weißmann, TI)**

EC-measurement delivers reliable values [mS/cm] 3 hours after slaughter at the earliest, although better prediction exists 24 -48 hours post mortem; EC-measurements earlier than 3 hours are not unusual in the practice but are less reliable.

pH on the other hand needs to be measured more or less shortly after slaughtering between a minimum of 30 minutes and a maximum of 1 hour post mortem; later pH-measurements, e.g. 24 hours, only serve as DFD-exclusion (dark, firm & dry pork), a different management induced meat quality defect which has nothing to do with PSE-syndrome.

Hence, pre-chilling PSE-detection is solely based on the pH and post-chilling PSE-exclusion is solely based on the EC-value system. The absence of PSE-conditions is indicated by pH exceeding or EC falling below threshold values presented in Table 1, used for German quality pork programs.

Table 1: Threshold values for PSE-exclusion in carcasses

Time of measurement	pH-value	EC-value
Loin (*Musculus longissimus dorsi*), 12th/13th rib		
30 min *post mortem*	≥ 6.1	- -
45 min *post mortem*	≥ 6.0	- -
50 min *post mortem*	≥ 5.9	- -
3 h *post mortem*	- -	< 5.0
5 h *post mortem*	- -	< 5.5
24 to 48 h *post mortem*	- -	< 6.0
Topside (*Musculus semimembranosus*)		
30 min *post mortem*	≥ 6.1	- -
45 min *post mortem*	≥ 6.0	- -
50 min *post mortem*	≥ 5.9	- -
3 h *post mortem*	- -	< 6.0
5 h *post mortem*	- -	< 6.5
24 to 48 h *post mortem*	- -	< 9.5

Environmental conditions influencing PSE

Beside these genetic reasons for PSE-susceptibility there are environmental conditions which can influence PSE events. Feeding and housing throughout the pigs' life have a negligible effect and the main environmental impacts can be considered as:

(i) pre-slaughter conditions,

(ii) slaughter technique, and

(iii) chilling.

Before slaughter

The most important pre-slaughter conditions to reduce the risk of PSE-conditions are gentle transport and feed deprivation prior to transport (no feed available for least 12 hours before); careful loading, driving & discharge; enough space for all pigs to lie down; not mixing different groups of pigs and optimal resting period at the abattoir. The common aim is to minimise glycogen reserves and temperature increase which both promote rapid glycogen metabolism (see above).

Stunning

Slaughtering involves stunning and subsequent withdrawal of blood. Stunning has to be done carefully, but effectively. Two systems are usual:

(i) with relatively high carbon dioxide (CO_2)concentration at the outset or

(ii) high voltage electrical stunning via head-heart-transmission of electricity

Chilling

Best practice in chilling is *shock chilling*. The carcass should be exposed to a blast of air at -5 to -8 °C for 120 minutes. If such a quick chilling procedure is not available, avoiding pigs' pre-slaughter heat increment (see above) becomes more important.

Fat consistency

A firm fat consistency is based on high levels of saturated and/or mono-unsaturated fatty acids in adipose tissue. A smooth or soft fat has more polyunsaturated fatty acids (PUFA), including essential fatty acids linoleic acid (C18:2n-6) and linolenic acid (C18:3n-3). Pigs, unlike cattle and sheep, are very efficient at transferring PUFA from their diet, so diets high in PUFA can lead to soft fat.

This must be taken into account when (i) a firm fat resistant to oxidation is desired for technological reasons (e.g. in the case of air-dried sausage production without anti-oxidative protection such as smoking), and when (ii) pig diets are expected to be energetically upgraded with PUFA-rich diet components like certain oilseeds. In both cases, there might be:

- *no problems, if pigs are fat with a low lean content.* High carcase fat levels are the result of the so-called *de-novo* fat synthesis mainly producing saturated and mono-unsaturated fatty acid, which dilute the PUFA, producing a firm fat (see above).
- *problems, if pigs are lean.* Due to low fat yield by the pigs, there is less dilution and dietary PUFA form a higher proportion of the body fat giving smooth, soft fat, susceptible to rancidity.

The interaction between dietary PUFA supply and body fat PUFA content is strongly correlated (r^2 >0.9). Figure 2 illustrates the interdependences. Usually, a PUFA fat content not exceeding 15 % is classified as sufficient in order to prevent oxidative fat spoilage. Hence, target carcass PUFA concentrations can be accurately predicted and controlled via dietary calculation including the choice of suitable feeds.

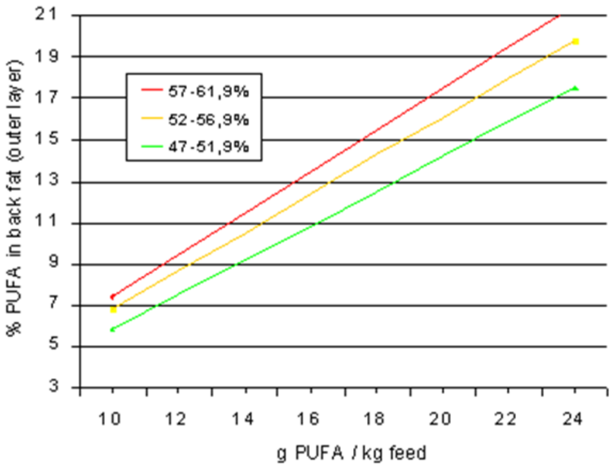
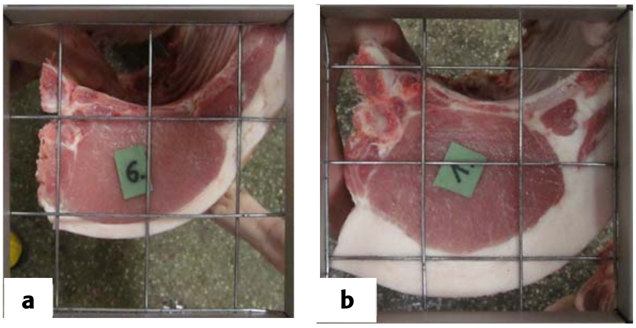


Figure 2. Relationship between PUFA content (linoleic & linolenic acid) in feed (13.5 MJ ME kg-1) and in the outer back fat layer (in % of all analyzed fatty acids) at 3 levels of carcass lean meat content (Fischer et al. 1992)

Sensory meat quality

Sensory meat quality such as tenderness, juiciness, and flavour are not rewarded in current pricing systems and most consumers are not really interested. Nonetheless, it is an intensively discussed subject and it depends on the degree of intramuscular fat content (IMF) and water binding capacity (WBC) of the meat, or basically its chemical and physical properties (compare Figure 1). However the general demand for lean meat does not promote an incentive for either.



Picture 3: Top views on loin (Musculus longissimus dorsi, 13th rib) from carcasses with (a) high (57.6 %) and (b) low (48.3 %) lean meat content. (Photo: F. Weißmann, TI)

Intramuscular fat

Intramuscular fat is closely correlated with overall body fat synthesis, mainly as subcutaneous fat. Hence, the higher the lean content of slaughtered pigs, the lower its intramuscular fat; regardless of whether the leanness is induced genetically (by breed) and/or dietary (by feed). Hence, it is not astonishing that IMF in pork loin (Musculus longissimus dorsi) rarely exceed 1.2 % to 1.5 % in current standard quality marketing systems in conventional and organic pork production. This is below the 2.5% considered necessary to generate higher sensory quality in tenderness, flavour, and juiciness with reasonable assurance. The associated loss of carcass quality in striving for high IMF, i.e. lean meat content, is the reason for the almost total lack of respective marketing initiatives.

Nevertheless, there are few examples of improving sensory meat quality, mainly by recommendation or even enforcement of Duroc as terminal sire-lines. Duroc genetics ensure a pork-typical meat colour with a dry meat surface and slight increase in intramuscular marbling associated with an acceptable increase in total fatness; altogether a clearly positive accentuation of pork image. Table 2 shows the effects of various terminal sire lines on selected carcass and meat quality characteristics.

Table 2: Carcass and meat quality characteristics of growing-finishing pigs from three terminal sire lines.

Terminal sire line	LMC[1] %	IMF[2] %	Drip loss[3] %	Juiciness points[4]	Tenderness points[4]	Flavour points[4]
Duroc	54.4	2.1	2.2	3.7	4.2	3.7
Pi-nn	56.8	1.4	3.5	3.3	3.8	3.4
Pi-pp	58.9	1.0	4.6	2.6	3.0	3.1

[1] Lean meat content via Fat-O-Meter;
[2] Intramuscular fat content of the loin (*M.l.d.*);
[3] 24 - 48 h *post mortem* (*M.l.d.*);
[4] worst = 1, best = 6 (*M.l.d.*)

Table 2 illustrates:

(i) the negative correlation between carcass and meat quality traits,

(ii) Durocs' positive influence on meat quality but simultaneously negative effect on economically very important lean meat content, and

(iii) the positive effect of MHS-gen sanitation (Pi-nn) on meat quality but inverse reaction on carcass quality compared to non-sanified Pi-pp and vice versa (compare also with the above mentioned remarks concerning PSE).

Another aspect of meat quality being addressed is the reduction of drip loss, since a high proportion of fresh pork is sold through self-service and consumers are aversed to puddles of meat juice in meat trays. Hence, drip losses below 4% within 24 to 48 hours after slaughter are targets for quality pork programs. Beside special breeding activities all management to avoid PSE are also beneficial in this respect (compare Table 2).

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