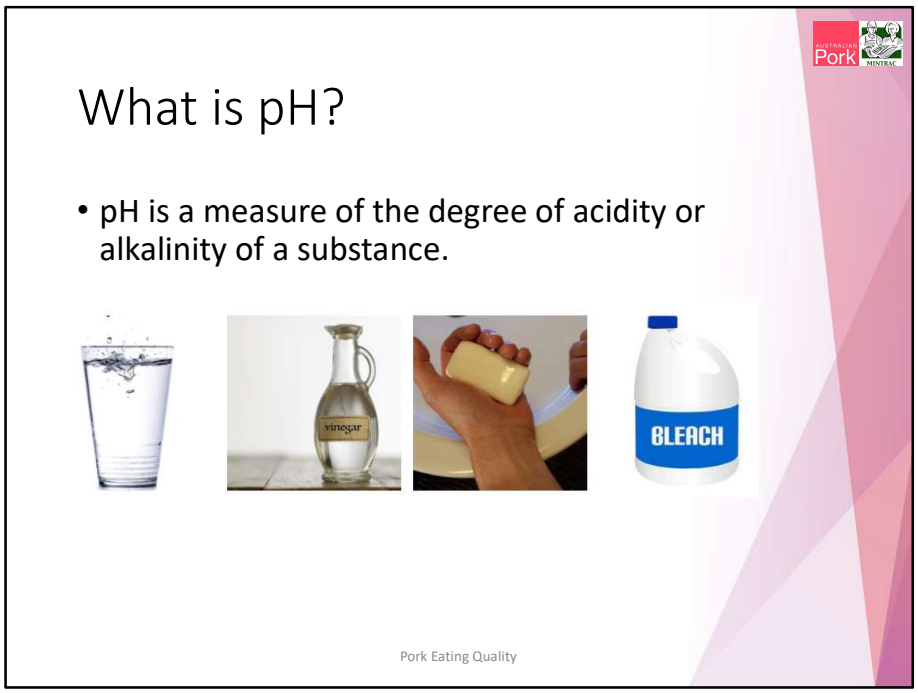
Pork Eating Quality Training

Outline of Training

1. pH, Glycogen
2. Measuring meat quality
3. Impacts on pH
4. Abattoir Procedures
5. Assessment

pH, Glycogen



pH is a measure of the degree of acidity or alkalinity of a substance. It is often represented as a rainbow, with red being more acid and violet being more alkaline.

pH is measured on a scale of 0.00 to 14.00. Pure water is neutral pH (7.00) represented by green on the rainbow scale. Battery acid would be around pH 0.20 (red), vinegar around pH 3.00 (orange). In the alkaline end, soap would be around pH 9 or 10.00 (blue), bleach pH 12.00 (indigo), and caustic soda pH 14.00 (violet-black).

In the live pig, the blood and body tissues are around pH 7.20-7.40, a little more alkaline than pure water because of the fats, proteins and minerals contained in them. In muscles and blood, the pH does not have a wide range, but very small changes of 0.20-0.50 pH unit can have a large effect on eating quality.

What is glycogen?

- Glycogen is the energy reserve of the muscle.

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Pork Eating Quality

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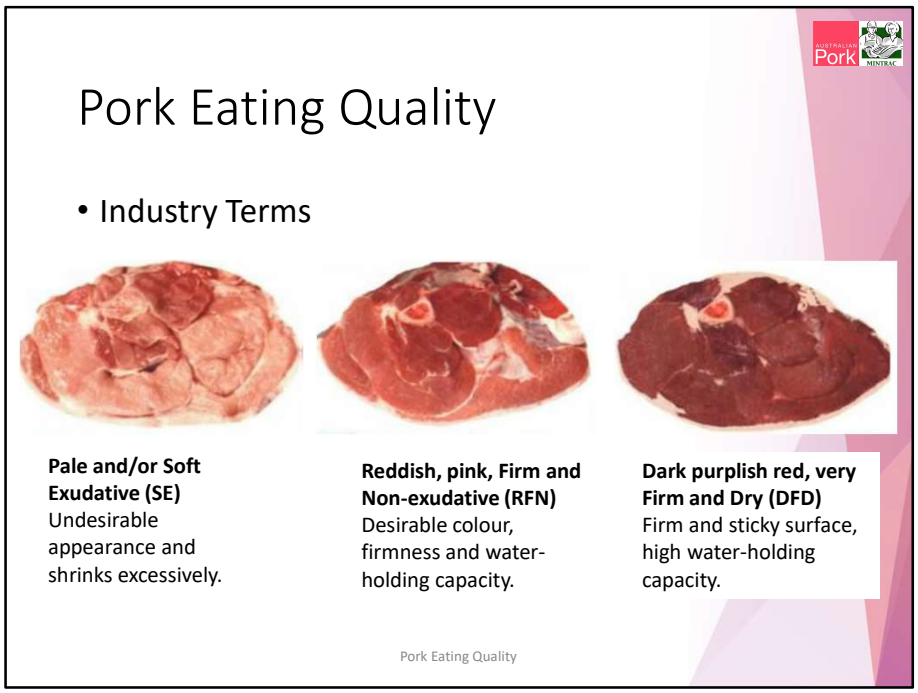
Every pig has a certain amount of energy contained in its muscles in the form of glycogen. Glycogen is broken down to release glucose into the bloodstream to be used as fuel for the cells.

The glycogen level in muscle is increased by feeding over a period of time. This store can be depleted rapidly (in minutes) by stress or activity in the live animal. The more glycogen that is present in the muscle prior to slaughter, the greater the potential for lower ultimate pH.

A number of factors can affect pork eating quality, with genetics, pre-slaughter handling, processing and carcass chilling having the greatest impacts. Before we look at these factors lets look at how pork quality is measured.



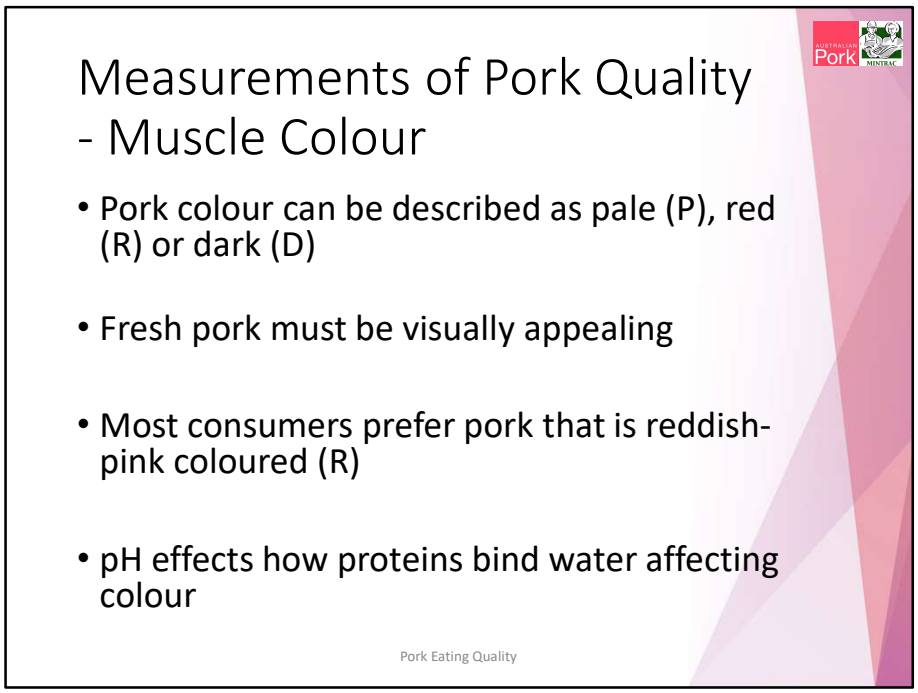
Pork classified as RFN has an ideal water holding capacity, colour and pH and is regarded, quality-wise, as normal. These traits are considered ideal due to their positive influence on eating quality and preferable appearance as a raw meat product. Less desirable quality classes are pale and/or SE and DFD.

Traits of pale and/or SE meat:

- tough
- watery
- 'two- toning' (unattractive retail appearance)
- reduced water holding capacity

Traits of DFD meat:

- extremely tough
- dry
- increased water holding capacity
- poor flavour development



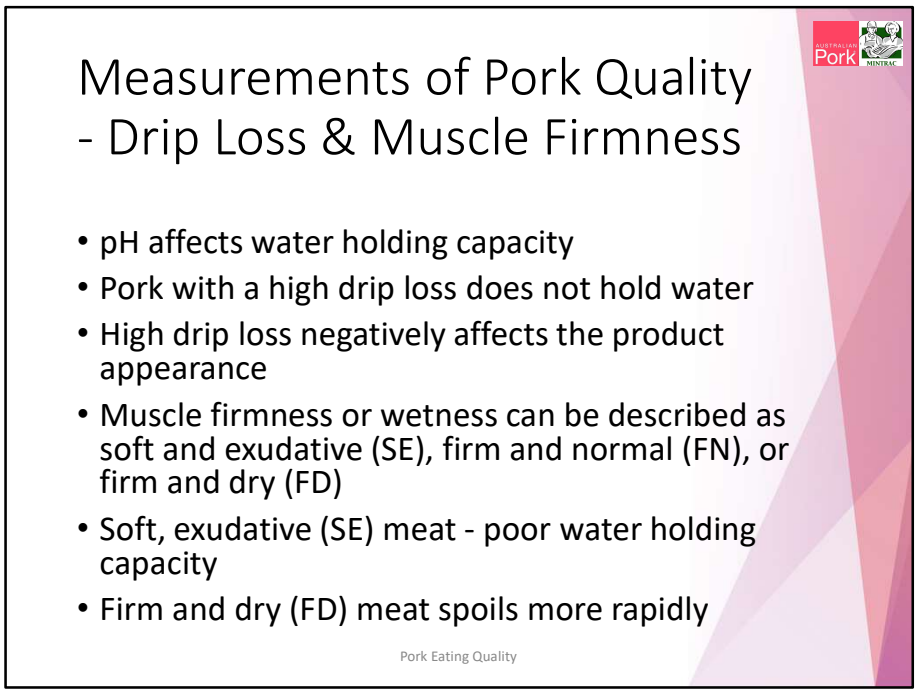
The main measurement of eating quality are muscle colour and drip loss and muscle firmness.

Pork colour can be described as pale (P), red (R) or dark (D).

Fresh pork must be visually appealing to the consumer, and meat colour makes the first impression.

Most consumers prefer pork that is reddish-pink coloured (R), as compared to pale (P) coloured pork.

Proteins in meat with a low pH (<5.40) do not bind water very tightly resulting in pale pork colour. On the other side, proteins in meat with higher pH bind water very tightly and result in a darker colour.



Drip loss & Muscle Firmness

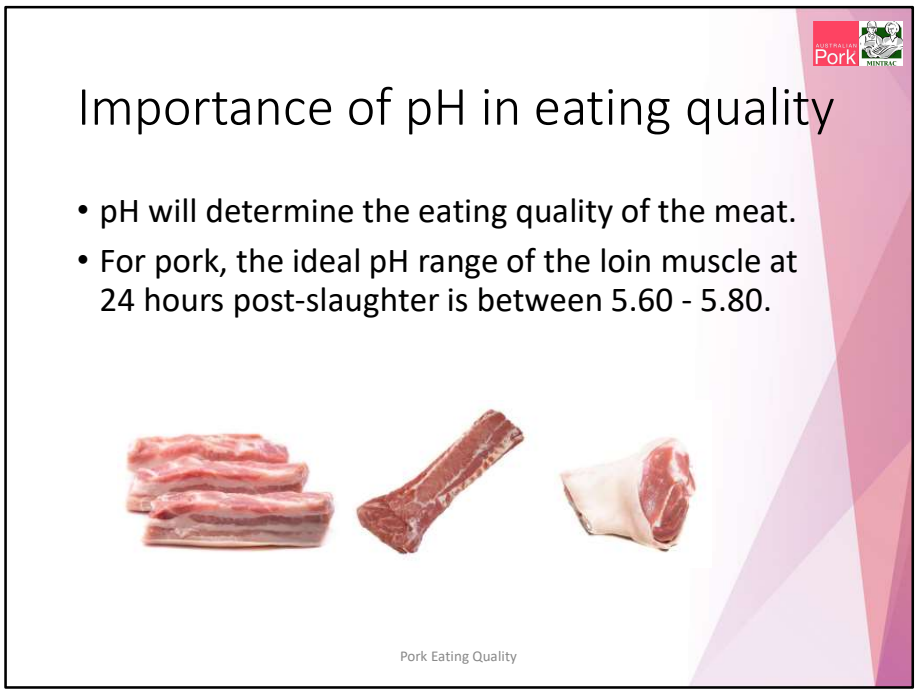
One of the traits that pH affects is water holding capacity. Water holding capacity determines both drip loss from raw pork and cooking loss during preparation. Pork with a high drip loss. i.e. does not hold water is undesirable for further processing as it results in yield loss and causes cooked meat to be dry. Lower pH results in high drip loss.

The appearance/presentation of packaged pork cuts with high drip loss negatively affects the product appearance and thereby the purchase intent.

Muscle firmness or wetness can be described as soft and exudative (SE), firm and normal (FN), or firm and dry (FD).

Soft, exudative (SE) meat is characterised by its poor water holding capacity. This means that it has a high drip loss, becomes tough and flavourless after cooking, and is not well suited for processing into products such as ham. Pork that is pale is not necessarily associated with SE characteristics.

Firm and dry (FD) meat spoils more rapidly and is less appealing to consumers.



Muscle pH influences the water holding capacity of meat, which affects the yield, colour, drip loss and pork quality. To achieve high eating quality meat you must manage the relationship between muscle pH and muscle temperature decline.

The pH of the carcase will determine the quality of meat and this is usually measured between 12 and 24 hours after slaughter. The amount of glycogen present in a carcase combined with chilling will affect the pH decline. If the pH in the meat falls too quickly or doesn't fall far enough, the meat quality will deteriorate.

For pork, the ideal pH range of the loin muscle at 24 hours post-slaughter is between 5.60 - 5.80.

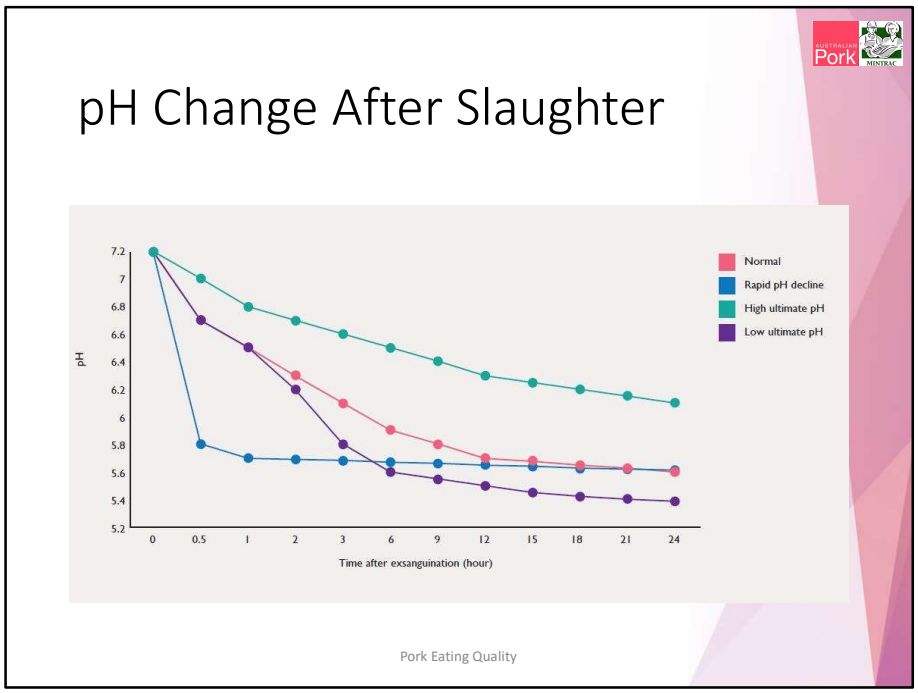
Rigor Mortis

- Rigor mortis is defined as when the carcase has exhausted its glycogen reserves or when the body reaches pH 6.00.
- For pork, the ideal pH range of the loin muscle at 24 hours post-slaughter is between 5.60 - 5.80.

Pork Eating Quality

Rigor mortis is defined as when the carcase has exhausted its glycogen reserves or when the body reaches pH 6.00.

Extensive consumer testing has proven that eating quality is negatively affected when carcases enter rigor mortis at a low temperature or at a high temperature. Lets now take a closer look at how the pH changes after slaughter and the factors that can be controlled to produce high eating quality pork

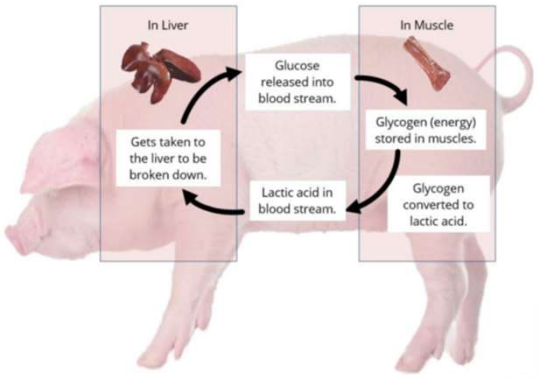


At slaughter, muscle glycogen is converted to lactic acid. After a pig is slaughtered the pH falls from pH 7.20-7.40 and the meat tissue becomes more acidic. This is because the cells in the muscles carry on doing their normal metabolism until they run out of energy.
The waste product made by the cells during this process is lactic acid. When the pig is alive, the blood circulation carries the lactic acid to the liver to be broken down.

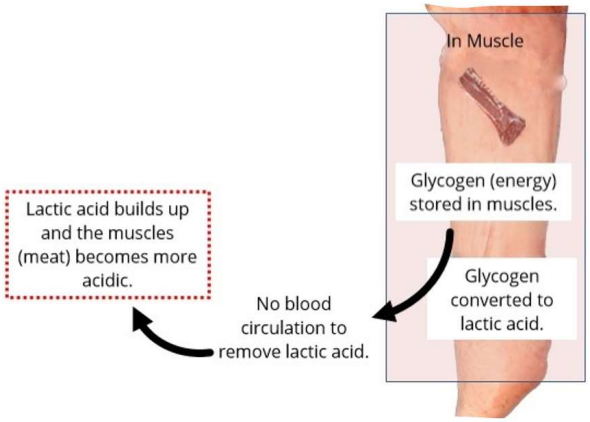
In the live animal, as well as removing built-up lactic acid in muscle cells, the blood circulation delivers glycogen to the cells to maintain a normal pH.
At slaughter, muscle glycogen breaks down to glucose and is converted to lactic acid. This causes an increase in the acidity of the muscle, reducing its pH. Once the pH decline has ceased, the ultimate pH is achieved.

For pork, the ideal ultimate pH is between 5.60–5.80. The pH range is quite small, so it is important to measure pH accurately.

Function of Glycogen - Before Slaughter

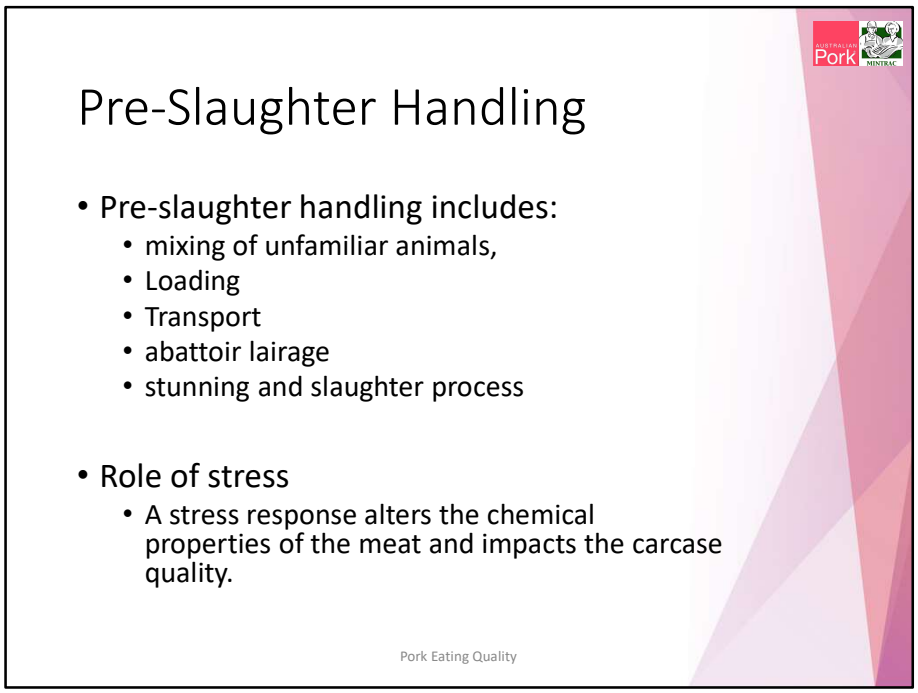


Function of Glycogen - After Slaughter



Research has found the major contributor to pH levels in pork is the many interactions that pigs experience throughout the whole supply chain.

Many factors throughout the supply chain can affect the pH of meat such as genetics, transport, pre-slaughter stress and post-slaughter chilling. On plant, you can maximise and control pork quality through careful handling before slaughter and rapid carcase chilling after slaughter. It is important to maintain the cold chain throughout processing.



The pre-slaughter period includes the total time required to move animals from the farm to the slaughter floor of an abattoir in preparation for slaughter.
Pre-slaughter handling starts on the farm and includes the mixing of unfamiliar animals, loading, transport, abattoir lairage and finally the stunning and slaughter process. These handling practices can all induce stress either psychologically or physically. Pre-slaughter stress is both an animal welfare issue and a meat quality issue.

Role of stress
When a pig perceives a threat, the stress hormones (cortisol and adrenaline) are released into the bloodstream which allows the animal to use energy to have a 'fight or flight' response. This energy is from glycogen. The glycogen is converted to glucose, and then into lactic acid. The lactic acid is the primary factor dictating the pH of muscle tissue.

A stress response alters the chemical properties of the meat and impacts the carcase quality.

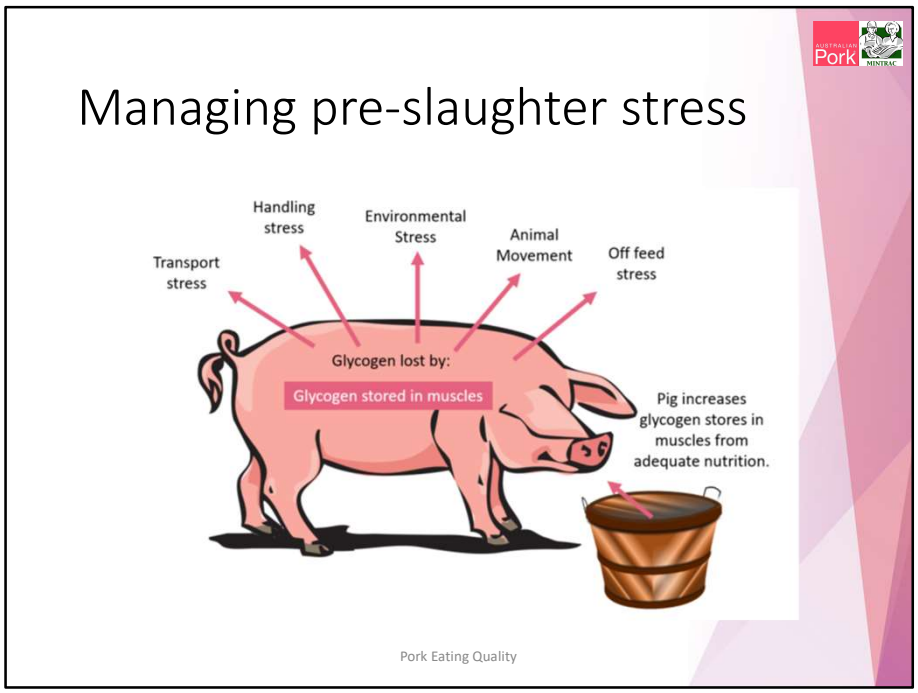
In a healthy and well-rested pig, glycogen levels in the cells are high at time of slaughter and the carcass pH will normally be around 5.60-5.80 when measured 12-24 hours after slaughter.

Pale and/or SE Pork

- If the pH drops below pH 5.50, this leads to paleness and the meat defect SE where muscle fibre firmness is lost.
- This happens in pigs that have plenty of glycogen in the cells but are acutely stressed (or exercised) at the point of slaughter. Excess lactic acid is produced and carcase pH falls below 5.50.

DFD Pork

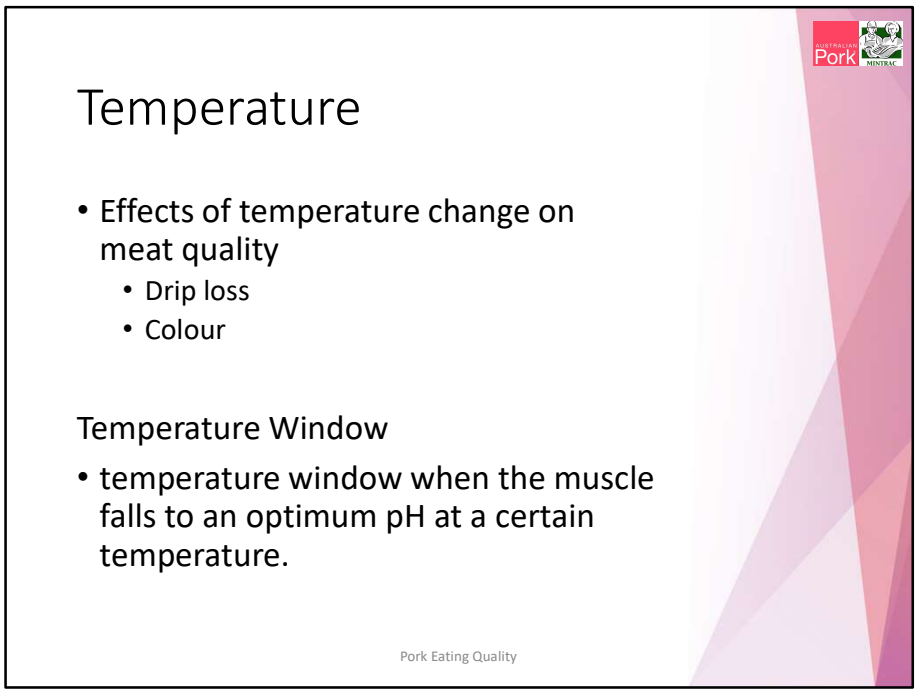
- If the pH doesn't drop below pH 6.00, the meat is dark in colour, tough and dry. This is when DFD occurs.
- In pigs that have had prolonged stress, or had a hard journey to the abattoir, the glycogen is used up before slaughter, and the bloodstream has mopped up the lactic acid. So, when they are slaughtered, there is no fuel to make more lactic



Ideally, the aim is to have pigs being slaughtered with as much glycogen in their muscles as possible, combined with minimal stress. This will help to ensure that muscle pH is kept within the optimum range for good meat quality. Listed below are some of the common stressors that pigs experience during transport and lairage. Have a look at your facilities and see where any improvements may be needed.

- Handling - Good facility design and automated handling equipment, quiet and competent stock handlers with minimal use of an electric prod or excessive force to move pigs. Are your stock workers working around the animals quietly?
- Environmental - Ensure that there is adequate air flow and the pigs are kept wet during hot days (>26oC). Pigs can't sweat so rely on panting and air flow over wet skin to keep cool.
- Off Feed - How long since the last ate? 12-15 h pre-slaughter fasting is common practice (including transport time). Pigs must be fed if they have been without feed for 24h as a welfare regulation with APIQ. Make sure pigs always have access to water.
- Movement - Mixing of unfamiliar animals should be avoided. Ensure your holding pens are providing sufficient space and adequate air flow in lairage facilities/holding pens
- Transport - The quality of the vehicle, ventilation, stocking densities and travel distance are important to consider. It is important to transport pigs when it is cool, and not to overload.
- Stunning - In general, muscles from electrically stunned pigs have a more rapid pH decline early post mortem whereas pH decline is normal when pigs are

stunned with CO2.



Pork quality characteristics like drip loss and colour are determined by the interaction between the rate and extent of post-mortem pH fall and temperature in the muscle.
High post-mortem muscle temperature in combination with a low pH can cause denaturation of muscle proteins resulting in a loss of water holding capacity and paler coloured pork.
When muscle temperatures fall quickly during chilling, the pH will usually only fall to pH 6.00. The cold temperatures 'shock' the muscle and causes massive muscle contractions. This causes the meat to become Dark, Firm and Dry (DFD).

Temperature Window
The pH temperature window is defined when the muscle falls to an optimum pH at a certain temperature.
pH is generally recorded as being the initial reading (45 minutes post-slaughter - at end of kill floor, before entering chillers) or between 12-24h. pH decline does not stop at 24 hours, however, the rate of decline after this period is very slow.
Therefore, it is very important to keep in mind 24 h pH is not ultimate pH.
With more data, a processing plant can measure after 6-8 hours after slaughter and

use a calibration equation to predict ultimate pH. Conducting pH declines gives an indication of the temperature that a carcase enters rigor mortis (pH 6.00).

Muscle Levels
Pigs with high levels of muscles will have a fast rate of pH decline regardless of processing conditions. There is also an effect on the temperature decline of these bodies. Animals with low levels of muscles will have slow rates of pH decline and high ultimate pH.

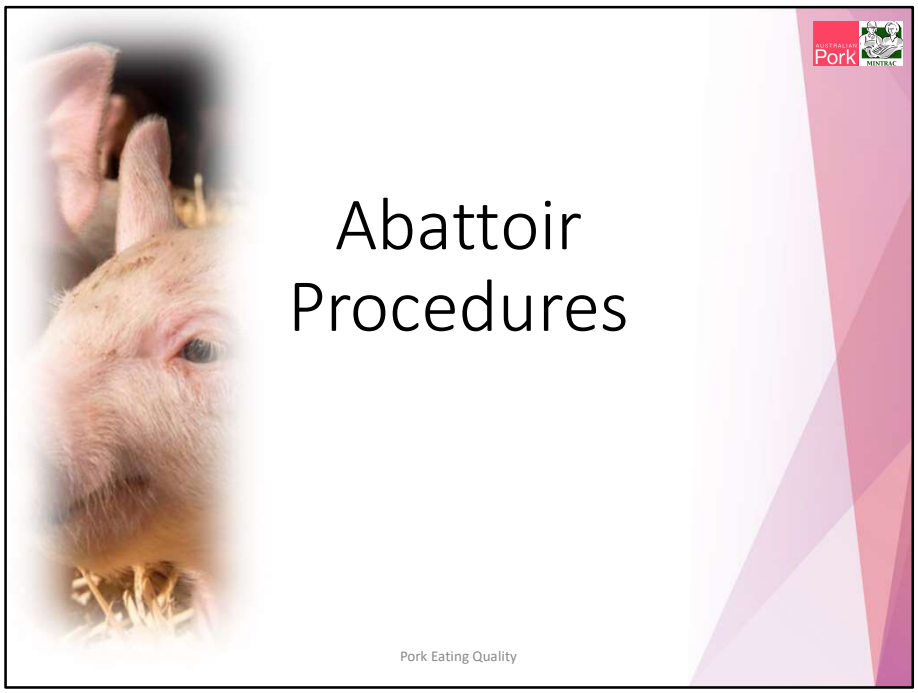
Carcase Weight & Fat cover
The heavier and fatter carcasses will cool more slowly than lighter, leaner carcasses. Heavier carcasses will therefore stay at higher temperatures for longer in the chiller. Rates of chilling may have to be adjusted through individual chiller temperature programs for heavier carcasses. Chillers should be managed so that heavier carcases go into chillers with colder settings, lighter carcasses with more moderate chilling programs. A recent audit of pork carcase pH suggests that correct carcass chilling is an important factor determining pH.

Breakdowns
Breakdowns that cause interruptions to line speed will likely contribute to low pH reducing meat quality, and also food safety if carcase temperatures are not quickly

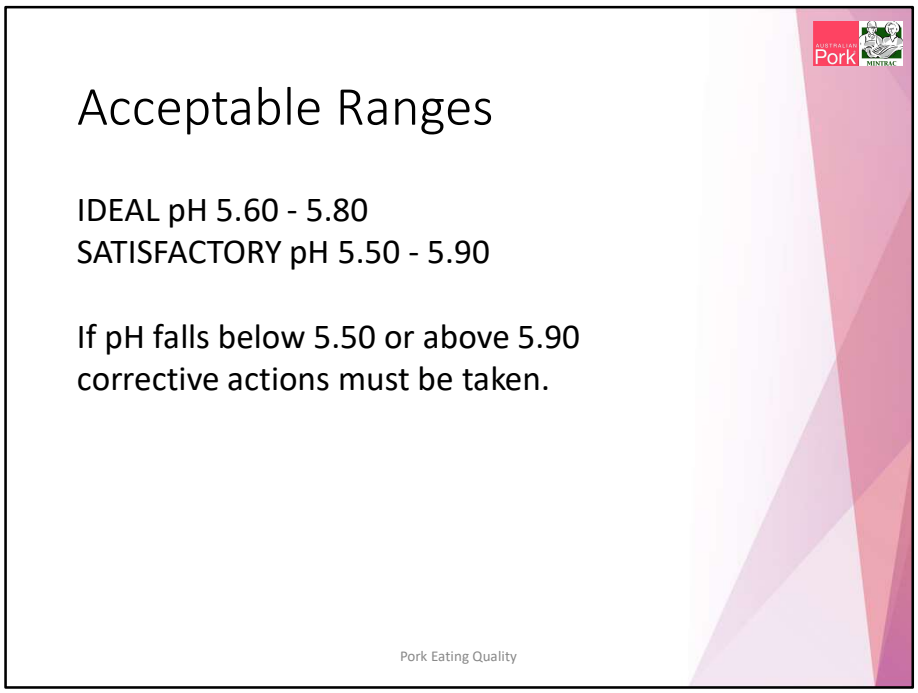
reduced post-slaughter.
When the carcases have passed through pH 6.00 before they reach the chillers, there is no way of reversing the effect on the quality of meat. Extremely cold chillers will have no effect once the bodies are below pH 6.00.

Temperature
The temperature of the kill floor – this will vary between seasons.
For example, during winter, cold kill floor temperatures may be conducive to DFD meat whereas, in summer, hot temperatures are favourable for pale and/or soft exudative (SE).
Therefore, it is important to monitor declines monthly to determine any seasonal changes and change processing conditions accordingly.

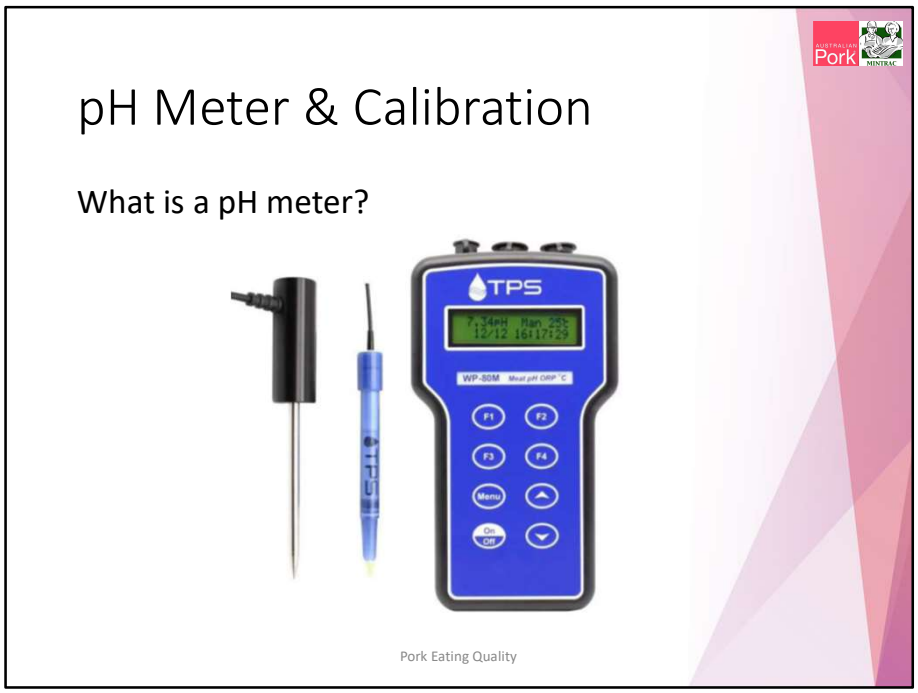
Chiller
Chiller loading
Under or over-loading a chiller can impact on the rate of temperature declines and could impact on quality.
Chiller/fan speed
Chiller/fan speed can impact on the rate of temperature declines and could impact on quality.
Chillers filled with different sized bodies
Smaller, lean carcases will cool more quickly than larger fatter bodies. Try to ensure even lines of carcases are in the same chiller. Larger bodies will remain hotter for longer, so ensure that carcases of even size and weight are chilled together and adjust chilling programs accordingly.
Bodies touching each other in the chiller
Some cuts will cool slower than others when bodies are touching and thus will be more susceptible to pale and/or soft exudative (SE)
Ensure there is sufficient space between carcases for ease of airflow around the whole body for even chilling rates.
Carcases placed in the direct path of chiller fans
In every case, some carcases will be more exposed to chiller fans than others. If possible, leaner carcases should not be directly exposed to the cold air of these fans.
Review chilling programs are appropriate for carcass grades regularly
Chilling cycles can also be reviewed and QA procedures will state what chill cycle is to be used for what category of carcases.



You must manage the relationship between muscle pH and muscle temperature decline to achieve high eating quality meat.



Conducting a pH/temperature decline measurement gives an indication of the temperature that a carcase reaches rigor mortis (pH 6.00) and what the likely ultimate pH will be.
The measurement of pH and temperature in the loin muscle from 12 to 24 hours post-slaughter can provide useful information to processors to determine whether issues with pork quality will be experienced – particularly colour, drip loss and tenderness.



A pH meter is a device that measures the changes in the activity of hydrogen ions in solution to measure the acidity or alkalinity of a solution or in this case a carcase. There are many different pH meters on the market and users should familiarise themselves with the equipment's instruction manual before using it. For the purposes of this training, we will use the TPS WP 80 M.
pH probes must be handled with care. The glass tip (and shaft) can be broken relatively easily.

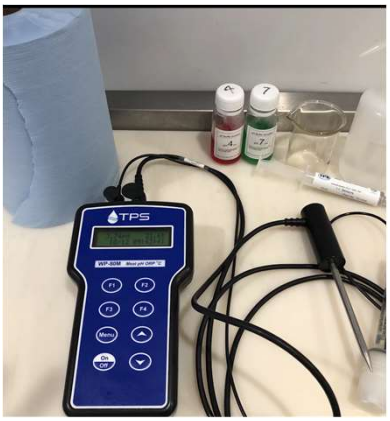
Temperature Probe
A temperature probe has a sharp tip to allow the user to push the probe into semi-solid product i.e. meat.
Waterproof
Meters and the connectors should be enclosed and fully waterproof.
Large Clear Display
That makes it easy to read and operate. 32 Character alphanumeric LCD with user-friendly menu system and full-text messages.
pH Sensor
pH range 0 to 14.00

Keypad

Waterproof keypad that allows you to perform various functions such as calibration, data logging, changing modes etc.

Calibration

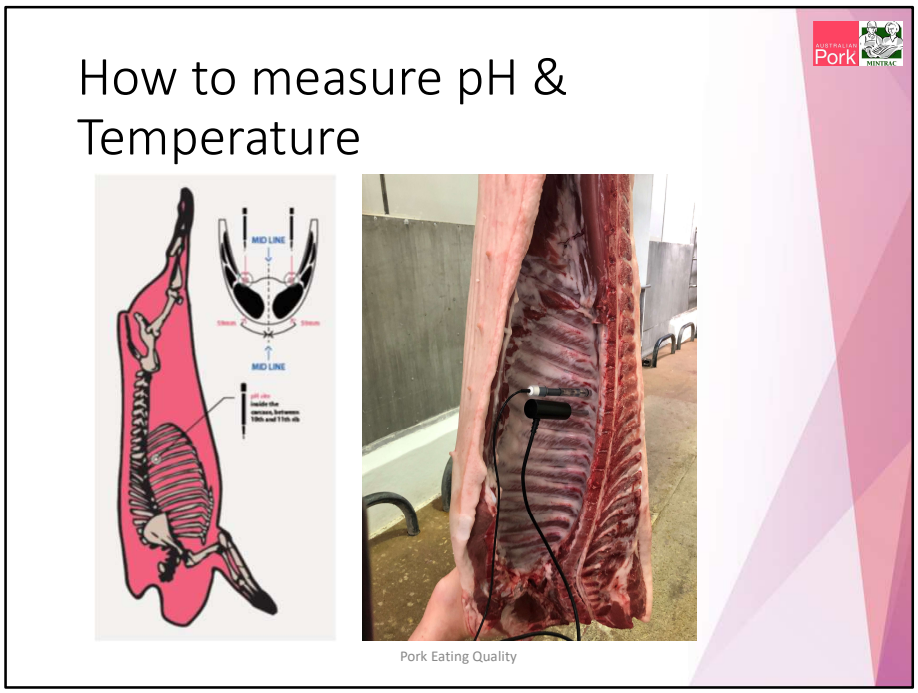
- Calibration is a critical step



Pork Eating Quality

Accurate pH and temperature measurements cannot be accomplished with a meter unless the meter has been calibrated. Without proper calibration, the meter has no way to determine the pH value of the solution/solid you are testing or the temperature. Calibrations need to be performed every time the pH meter is used.

A pH meter must be calibrated each time a series of readings is performed. Failure to calibrate properly will mean wasted time and effort and meaningless results. Accurate pH measurements cannot be accomplished with a pH meter unless the meter has been calibrated against standardised buffer. Without proper calibration, the meter has no way to determine the pH value of the solution/solid you are testing.
There are two methods of calibration, a one-point and a two-point calibration. A two-point calibration is a more accurate calibration technique than the one-point calibration. The two-point calibration adjusts the meter at two different pH values whereas the one point only uses one pH value.
A full 2-point calibration must be performed each time a series of readings is performed.



The carcase temperature and pH must be measured simultaneously because muscle pH is temperature dependent. Meat quality is impacted by the rate of pH and temperature decline. Temperatures can fall rapidly and impact on the ultimate pH. The pH can decline rapidly when the temperature is high. It's ideal to use a pH meter fitted with a temperature probe.

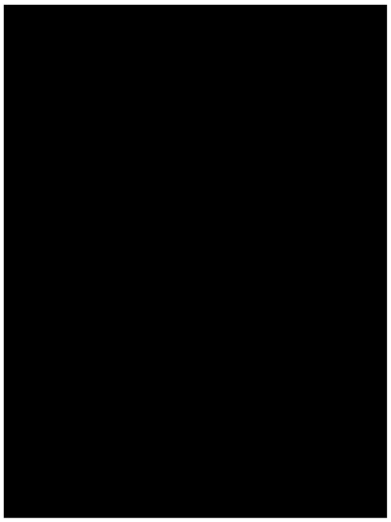
To measure the pH and temperature of a pig carcase it is done in the loin muscle:

- between 10th and 11th rib
- from inside the carcase
- 59 mm away from the midline of the carcase
- avoiding the end of the tenderloin
- hold the probe here until the reading is complete

The measurement is done between 12 and 24 hours post-slaughter.
The muscle temperature should be recorded to one decimal place (e.g. 35.3°C) and the muscle pH to two decimal places (e.g. 5.55).
Loin muscle pH taken at 8-12 hours could normally be expected to be between 5.40 to 6.10. If it is outside this range, the measure should be taken again in a slightly

different spot on the loin or on the opposite carcase side.

How to measure pH & Temperature



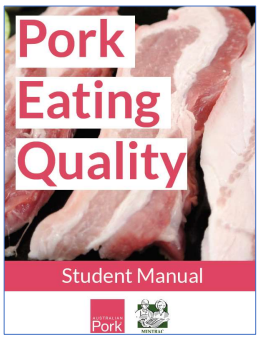
Data download

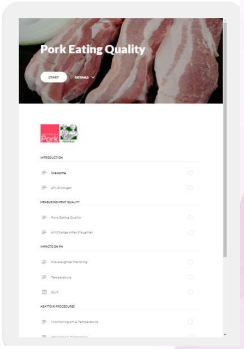
03/12/2018	09:34:00	13	,	6.09pH	1.9oC
03/12/2018	09:34:24	14	,	5.75pH	1.9oC
03/12/2018	09:35:32	15	,	5.63pH	2.0oC
03/12/2018	09:36:15	16	,	5.87pH	2.1oC
03/12/2018	09:36:45	17	,	5.65pH	1.9oC
03/12/2018	09:37:49	18	,	5.60pH	1.9oC
03/12/2018	09:39:07	19	,	5.82pH	1.8oC
03/12/2018	09:40:58	20	,	5.78pH	2.1oC
03/12/2018	09:42:01	21	,	5.67pH	2.2oC
03/12/2018	09:43:55	22	,	5.72pH	2.0oC
03/12/2018	09:54:18	23	,	5.90pH	2.3oC
03/12/2018	09:55:20	24	,	5.75pH	2.1oC
03/12/2018	09:56:10	25	,	5.61pH	2.3oC
03/12/2018	09:57:01	26	,	5.51pH	3.0oC
03/12/2018	09:57:47	27	,	5.62pH	3.0oC
03/12/2018	09:59:33	28	,	5.73pH	3.1oC
03/12/2018	10:00:12	29	,	5.72pH	2.6oC
03/12/2018	10:01:11	30	,	5.78pH	2.7oC
03/12/2018	10:02:49	31	,	5.70pH	2.5oC
03/12/2018	10:03:01	32	,	5.62pH	2.5oC
03/12/2018	10:04:10	33	,	5.95pH	2.1oC
03/12/2018	10:05:13	34	,	5.70pH	2.5oC
03/12/2018	10:06:18	35	,	5.82pH	2.7oC
03/12/2018	10:07:25	36	,	5.85pH	2.8oC
03/12/2018	10:08:23	37	,	6.10pH	2.5oC
03/12/2018	10:09:52	38	,	5.67pH	2.6oC
03/12/2018	10:11:58	39	,	5.65pH	2.1oC
03/12/2018	10:13:53	40	,	5.69pH	2.7oC
03/12/2018	10:14:49	41	,	5.61pH	3.1oC
03/12/2018	10:15:47	42	,	5.62pH	3.1oC
03/12/2018	10:17:15	43	,	5.66pH	3.1oC

The pH meter will store these readings to download later onto a computer.
This can be downloaded into excel to allow you to monitor pH over time and carry out further analysis.

Further Resources

- Training Manual
- Pork Eating Quality eLearning





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