

METTLER TOLEDO APPLICATION NOTE

pH Measurement In Meat Using A Puncture Electrode

BACKGROUND

Direct pH measurement in meat after slaughter is a quick, reliable and meaningful method for judging quality. The following properties are quality criteria that are directly or indirectly affected by the pH value:

- color
- tenderness
- flavor
- water binding properties
- shelf life

Additionally, the pH value aids in determining if the meat is suitable for processing.

THE PROCESS

The pH of living muscle lies at 7.2 pH. After slaughter, biochemical breakdown processes take place in the meat. The energy carrier in muscle (glycogen) is broken down into lactic acid by various enzymes (glycolysis) which causes a drop in the pH of the meat.

When the glycogen breakdown takes place too quickly, it causes hyperacidity of the muscle. This is referred to as PSE (Pale Soft Exudative) meat, defined as exhibiting a pale color and poor water binding properties. Because the color

change begins later, pH measurement shortly after slaughter (called pH₁) is preferred.

When the energy carrier of the muscle is exhausted, less lactic acid can be formed. This results in a dry, firm, glutinous, so-called DFD (Dark Firm Dry) meat with change in flavor and reduced shelf-life capability. DFD meat can be determined by pH measurement 16 – 30 hours post mortem, called pH₂₄ (or pH₃₀).

Fig. 1: pH pattern for PSE, normal and DFD

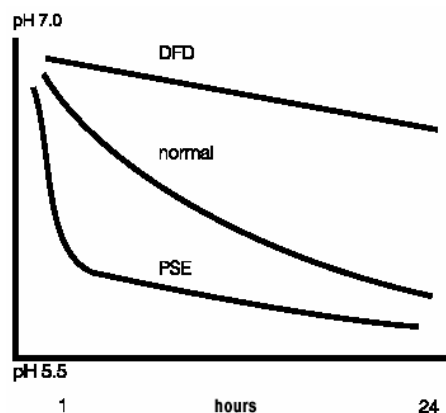


Table 1: Characteristic properties of PSE and DFD meat

| Property | PSE meat | DFD meat |
|---|----------------------|-------------------|
| glycolysis, pH drop | very quick | slow, incomplete |
| pH ₁ value | < 5.6 | ≥ 6.0 |
| pH ₂₄ value | - | > 6.2 |
| color | bright, pale | dark |
| consistency | soft | firm, glutinous |
| water binding properties | low, watery | high |
| loss of gravy (most of all while hanging) | high | low |
| shelf-life | occasionally reduced | generally reduced |

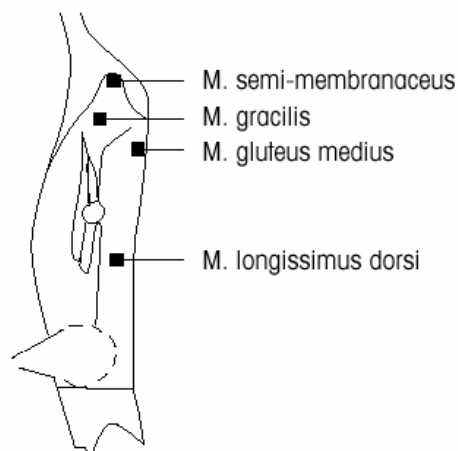
Measuring of pH₁ shortly after slaughter:

The pH measurement can be carried out directly in the carcass. It helps to detect PSE meat as early as possible. Although reliable results about the quality are possible as early as 20 minutes after slaughter, the pH₁ measurement usually takes place 45 – 60 minutes post mortem.

Measuring position of pH₁:

Since ripening of each individual muscle is non-uniform, the pH values in different muscles are dissimilar. Preferably the pH measurement is carried out in the chop (M. long. Dorsi, height of 10th dorsal vertebra), because this is the position where PSE changes occur most often (see Fig. 2).

Fig. 2: Measuring position of pH₁



Procedure: Insert the electrode 5 cm into the longissimus dorsi muscle at the height of the 10th dorsal vertebra near the fat layer and read the pH value. Meat of pigs, bulls, calves, and sheep can be classified 45 – 60 minutes after slaughter by direct pH measurement as follows:

Table 2: pH₁ (45 – 60 minutes after slaughter)

| Criterion: | extremely PSA | suspected PSE | tolerable | normal or DFD |
|------------------------|---------------|---------------|------------|---------------|
| pH ₁ value: | < 5.6 | 5.6 - 5.79 | 5.8 - 5.99 | ≥ 6.0 |

Example 1: pH value in pork meat shortly after slaughter

When pigs are exposed to stress before and during slaughter, low pH values are measured.

Table 3: pH range of PSE pork meat

| Time p.m. (between anaesthetization and pH measurement) | pH range of PSE meat |
|---|-----------------------|
| 20 - 25 minutes | pH ₁ < 5.8 |
| 30 minutes | pH ₁ < 5.8 |
| 45 - 60 minutes | pH ₁ < 5.6 |

Measuring of pH_{24} value 16 – 28 hours after slaughter:

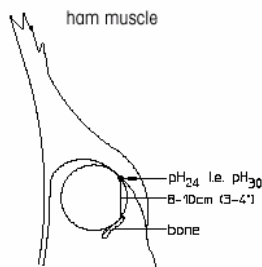
Due to easy access in the dissected carcass and its reliable result for judging meat quality, pH measurement is done in the dorsal muscle (M. longissimus dorsi) and the ham muscle (M. semimembranaceus) near the fat layer. This measurement is carried out 16 – 28 hours after slaughter and together with the results of pH_1 measurement allows the classification of the meat:

- DFD meat with an increased pH value
- Normal meat with a mid-range pH
- PSE or sour and spoiled meat with a low pH

Measuring position of pH_{24} (or pH_{30}):

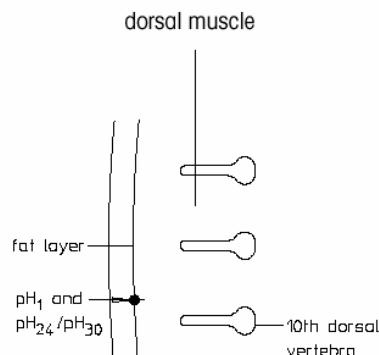
Usually M. long. Dorsi and M. semimembranaceus

ham muscle, M. semimembranaceus



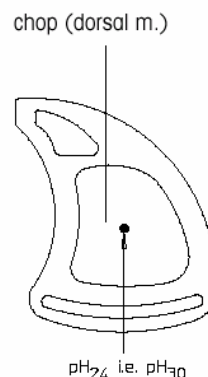
Insert the electrode 2-3 cm deep under the fat layer into the ham muscle and read the pH value.

dorsal muscle, M. longissimus dorsi



Insert the electrode 5 cm deep at the height of the 10th dorsal vertebra into the dorsal muscle and read the pH value.

dorsal muscle (chop), M. longissimus dorsi



Insert the electrode 2-3 cm deep directly into the muscle of the chop and read the pH value.

Table 4: pH_{24} (16 – 28 hours after slaughter)

| Criterion: | DFD meat | normal meat | sour and spoiled meat |
|----------------------|----------|-------------|-----------------------|
| pH_{24} pork: | > 6.2 | 5.3 - 6.2 | < 5.3 |
| pH_{24} beef/veal: | > 6.0 | 5.4 - 6.0 | < 5.4 |

Example: pH_1 and pH_{30} value of pork meat

Table 5: Classification with pH_1 and pH_{30} of pork meat

| extremely PSE or DFD | suspected PSE | tolerable | normal |
|------------------------------------|--|--|-----------------------------------|
| $pH_1 < 5.6$ or $pH_{30} > 6.2$ | pH_1 5.6 - 5.79 and $pH_{30} < 6.2$ | pH_1 5.8 - 5.99 and $pH_{30} < 6.2$ | pH_1 6.0 and $pH_{30} < 6.2$ |

INSTRUMENTATION

The combination puncture pH electrode LoT406-M6-DXK-S7/25 provides quick, reproducible, and accurate values. The rugged needle-shaped tip of the electrode has been specially designed for puncture measurement in meats, cheeses, and other solid foods. The puncture electrode features a Xerolyt[®] solid polymer reference which has been formulated to maintain a stable potential for accurate and repeatable pH measurement and extend electrode lifetime up to five times. Use of the solid polymer reference permits an open aperture (junction) instead of the conventional ceramic junction, which allows the electrolyte and medium to be in direct contact. This aperture is much less likely to become clogged

(which delays response time) than the fine pores of a ceramic diaphragm, making it particularly suitable for measurements in solid foods. A plastic enclosure of FDA positive listed PBT protects the electrode from mechanical stress.

An additional knife style attachment is available for use in firmer applications to protect the needle tip from accidental breakage.

Mettler Toledo Process recommends the Model 1120/1140 Portable pH Meter for use with these electrodes. These meters feature a waterproof enclosure suitable for measurements in very humid environments.

PRODUCTS

1120 or 1140 Portable pH Meter

- Rugged, portable design allows use in a variety of applications and environments
- Sensor & transmitter diagnostics for process safety
- Logbook for adherence to QM documentation and procedure requirements
- FM certification for Class I, Div. 1 Environments

Lot406-M6-DXK-S7/25 Puncture pH Electrode

- Specially designed for pH measurement in meat, sausage and cheese
- Rugged, needle-shaped membrane may be used to penetrate foods for quick, accurate measurement
- Patented Xerolyt[®] solid polymer reference system maintains a stable potential for accurate and repeatable pH measurement and low maintenance
- Open junction eliminates reference clogging by proteins and fats, extending sensor life
- Optional knife mount for easy puncture and penetration for food surface

GLOSSARY

| | | | |
|-----|---|------------------|--|
| PSE | (Pale Soft Exudative) meat Pale, bright, watery meat of animals being exposed to stress before and during slaughter. | p.m. | post mortem |
| | | pH ₁ | First pH value, 45 – 60 min. after slaughter |
| | | pH ₂₄ | pH value, 16 – 28 hours after slaughter |
| DFD | (Dark Firm Dry) meat Dark, firm, dry, glutinous meat of exhausted animals with low energy carrier in the muscle. | pH ₃₀ | pH value, 24 – 30 hours after slaughter |
| | | FDA | Food and Drug Administration |
| M. | Muscle | PBP | Polybutyleneterephthalate |

LITERATURE

K. Hofmann: "pH. A quality criterion for meat"; Fleischwirtschaft, 1988, Vol. 68 (1), p. 67 – 70.