pH Application Note

pH Measurement of Meat

InLab Solids Pro-ISM Sensor

The pH of meat serves as a direct indication of its freshness, taste and overall quality. Because of this, the meat industry requires recording the pH measurement of the samples during quality evaluation, processing and packaging. A conventional pH sensor with a ceramic junction can get easily clogged and is difficult to clean which can lead to sensor fouling and inaccurate results. It requires tedious sample preparation for determining the pH. By adjusting the sensor design, like in METTLER TOLEDO's InLab Solids Pro-ISM, the functional components of the sensor are modified to measure meat samples by direct insertion and to handle other measurement challenges promptly. The ultimate result is faster and more accurate pH determination of meat samples.

METTLER TOLEDO

Introduction

Various qualities in the final product of the meat such as tenderness and juiciness depend on its pH value. In a meat sample, intrinsic parameters such as pH, water binding capacity, presence of salts and temperature determines its palatability, freshness and potential to develop microbial growth. Regulatory bodies like EFSA (European food safety authority) and FSSAI (Food Safety and Standards Authority of India) enlist pH determination as a physico-chemical quality check for meat and meat products. pH values are normally mentioned in their manuals as a standard reference. Typical pH values listed are as follows:

Product	pH value (range)
Raw fermented sausage	4.8 to 6.0
Beef	5.4 to 6.0
Pork	5.5 to 6.2
Canned meats	5.8 to 6.2
Curing brines	6.2 to 6.4
Muscle tissues	7.0 to 7.2

Importance of pH Measurement

In the absence of oxygen, as in the case of animal death, glycogen from the body cells gets converted to lactic acid. This biochemical process leads to a decrease in pH and can occur in as little as one hour, depending on the type of animal, breed and other factors. Fresh meat has a pH value betwee 5.5 to 6.2 or as listed in the reference table above based on the meat type. A pH value below 5.3 indicates rancidity of the sample due to poor storage and improper preservation.

Two undesired qualities of meat are PSE (Pale Soft Exudative) and DFD (Dark firm and Dry), because the color and texture of meat is directly related to its pH value. PSE in pigs is caused by severe stress just prior to slaughter, leading to pale colored meat that is poor in flavor. pH of such meat is acidic and is around 5.4 -5.6. On the other hand, in DFD meat which is dark colored, is not acceptable to consumers and has a poor taste. pH of such meat is high and is around (6.4 -6.8). The water-binding capacity of meat is another important parameter of meat quality and is influenced by pH. High pH leads to increased water retention. Depending on the end use of the meat, like in production of sausages, it is maintained at the required pH, so as to keep the water-binding capacity right.

To inhibit the growth of pathogenic bacteria and in order to increase the shelf life of meat, a curing technique is sometimes adopted by adding nitrates/ nitrites. Each pH unit decrease corresponds to a ten-fold increase in the antimicrobial activity of nitrites. Hence the pH determination is required here for further processing of meat, correlation of water binding capacity, and monitoring the acidity due to added ingredients like nitrites. pH also helps to control the ripening process in raw fermented meat products.

Measurement Challenges

Meat samples that are solid in nature require sample preparation before pH measurement. Mincing the meat and blending it into a paste is the standard procedure. Such sample preparation procedures leave a high scope for introducing errors. Unstable pH values due to sensor fouling is another common problem faced for such samples.

The table below outlines the challenges and negative effects on pH measurement results when using a typical sensor.

Sample Challenge	Sample Impact
Solid sample nature	Direct insertion into the sample is difficult.
Sample preparation	Alternate method includes grinding and blending of meat sample and is time consuming.
High protein sample content	Sensor junction damage due to clogging, causes inaccurate results.
High fat sample content	Sensor fouling due to deposition on the glass membrane, causes sluggish response.

High fat and protein content from meat sample accumulate on the sensor's glass, thereby preventing the sample from interacting with the membrane to initiate a signal. Classical silver/silver chloride reference systems can cause protein precipitation due to free silver ions in the electrolyte. When such precipitation occurs, a typical ceramic fritted junction will clog, preventing electrolyte from mixing with the sample and thereby causing measurement error.

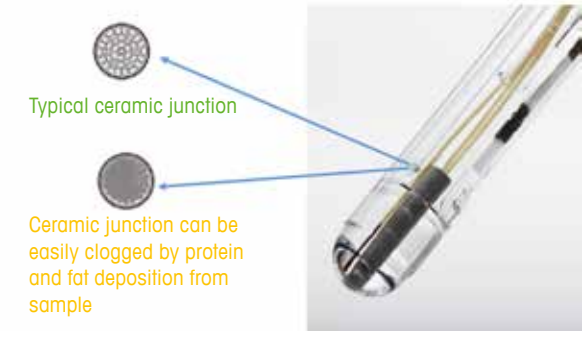

Figure 1: Sample impact on a conventional pH sensor having a ceramic junction

The solid nature of meat samples can introduce sample-handling challenges for the user. Delicate sensing membranes can get scratches during the measurement process. For this reason, alternate method of indirect measurement techniques are used, wherein the sample is grinded into paste by adding water. However, the most accurate method of pH measurement in meat is direct measurement, where the sample remains unprocessed, subjected to least physical stress.

Right Piercing for Quick and Reliable pH

InLab Solids Pro-ISM (51344155) is a specialist sensor for measuring pH of meat in terms of accuracy and precision. The pH sensing membrane is constructed from low temperature (LoT) glass, which yields fast results and is resistant to breakage. The solid XEROLYT®EXTRA polymer reference system offers two benefits: it is low maintenance, and has a clog-free open junction, which eliminates the risk of protein fouling.

Figure 2: InLab Solids Pro-ISM pH sensor

The spear shaped sensor tip is designed for easy piercing into the solid meat samples. It pierces the meat aptly for sufficient penetration without traumatizing the specimen cells. This sensor features an improved reference system, ARGENTHAL™. The silver ion trap in it takes care of silver ions from migrating into the electrolyte. The proteins from meat sample can now freely interact with the electrolyte without causing precipitation.

The sensor has Intelligent Sensor Management (ISM) technology that offers data security, stores calibration history and monitors maximum temperature exposure of the sensor. 'Pro' stands for a built-in temperature probe in sensor that helps to capture the sample temperature accurately and supports the ATC (automatic temperature compensation) functionality. pH measurements are highly temperature dependent. For an accurate pH value, the pH calibration slope needs to be corrected to measurement temperature. By the virtue of ATC, this is attained so as to take care of the influence of temperature dependence on the sensor and pH system. For example, while measuring a sample at 15 °C, the right temperature ensures the calibration slope is corrected to represent the system performance at 15 °C. However, the pH value measured at 15 °C would differ from the pH value at 35 °C, as the ionic activity of the sample varies with temperature.

Procedure and Method

Calibrate the sensor using buffers that bracket the sample range (in this case pH 4.01 and 7.00). Record the calibration slope and offset value for the electrode. A slope value of 95 -105 % and an offset of 0 ± 30 mV ensures reliable measurement.

Figure 3: Measuring pH of poultry sample using InLab Solids Pro-ISM pH sensor

A small representative piece of meat sample is taken for measuring the pH. Pierce the piece of meat sample with InLab Solids Pro-ISM pH sensor. Alternatively, a slit can be made to ease the sensor insertion into the sample. Care must be taken to ensure proper contact of pH sensor tip and junction with the meat sample. Repeat the measurement at various positions to obtain a representative pH reading. A standard deviation within ± 0.05 pH units indicates fair variance in the pH measurement of meat sample.

Results and Discussion

Typical measurement result of meat samples (in triplicates) using InLab Solids Pro-ISM Senor.

Sample	Mean pH value	Std. Dev.	Avg. time (s)
Goat meat	6.10	0.01	45
Pork	5.82	0.03	24
Chicken	5.70	0.03	17

Table 1: pH values of meat samples measured with InLab Solids Pro-ISM Senor.

Repetitive pH measurements may lead to protein built-up and sensor surface contamination resulting in slow response. Proper care and maintenance of electrode helps to overcome this sluggish behavior.

Expert Tips

- For thorough cleaning, wash the electrode with mild soapy solution, and later rinse it with de-ionized water.
- Regular maintenance is very important for prolonging the lifetime of pH electrode. Periodic reconditioning of the electrode in 0.01M HCl is recommended, based on the sensor performance. Frequency of reconditioning would depend upon the number of samples analyzed per day and life of the sensor. Old sensor requires more frequent conditioning compared to a newer sensor. Remember to re-calibrate the sensor after reconditioning.
- It is recommended to soak the sensor in pepsin/HCl solution (51350100) for one hour once a week to remove protein build up on the glass membrane.
- The pH range for this sensor is 1 to 11 pH units and hence should not be exposed to harsh acidic or alkaline chemicals.
- In between measurements or when the electrode is not being used for brief period, it is best to keep the electrode in wetting cap filled with InLab Storage Solution (30111142).
- Never store the electrode dry or in distilled water, as this affects the pH-sensitive glass membrane shortening the lifetime of the electrode.

Further Information

- Electrode handling movies on:

YouTube

- Comprehensive range of pH meters, electrodes, solutions, and accessories:
  www.mt.com/pH

References

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Document Number 30553179
Group MarCom 2723 AG