pH Application Note

pH of Fruits and Vegetables

InLab Solids Pro-ISM Sensor

pH measurement of fruits and vegetables is used by various processing and canning industries. Analysis includes pH determination in a whole, fresh cut, frozen, or canned fruit or vegetable. Recording a reliable pH is cumbersome with a conventional pH electrode which has a ceramic junction and a standard shaped glass membrane. Such junctions get clogged easily and the sensor cannot be directly inserted in the fruit or vegetable, leading to inaccurate and sluggish results. METTLER TOLEDO's InLab Solids Pro-ISM is specially modified to measure pH through easy piercing into such samples. The sensor design also enables a faster and accurate analysis with adept functional components like open junction, solid electrolyte and a sensitive pH membrane.

Introduction

Fruits and vegetables are best enjoyed when they are fresh. Freshness also indicates maximum nutritional benefit. Fruits and vegetables preservation is carried out by canning, pickling or freezing. pH information helps to ensure the shelf life and freshness of these products.

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Fruits

Most fruits have low to medium acid level pH values. Fruits are rich in organic acids like citric acid, lactic acid and malic acid. The presence of these acids makes a fruit acidic in nature. Apart from the typical organic acids that form the flavor of the fruit, scientific study suggests that organic acids like lactic acid and acetic acid are generated along with ethanol when a fruit over ripens and the sugars ferment due to microbial action. Approximate ranges of pH values for fresh fruits as per LACF (low-acid canned foods) cordinator of FDA (Food and Drug Administration), US gov. are listed below.

Product	pH value (range)
Apples	3.30 - 4.30
Bananas	4.50 - 5.29
Cantaloupe	6.13 - 6.58
Jackfruit	4.80 - 6.80
Oranges	3.69 - 4.34
Papaya	5.20 - 6.00
Pineapple	3.20 - 4.00
Watermelon	5.18 - 5.60

Vegetables

Most vegetables have medium to moderate pH levels, ranging from acid to akaline. Approximate ranges of pH values for vegetables as per LACF (low-acid) canned foods cordinator of FDA (Food and Drug Administration), US gov. are listed below.

Product	pH value (range)
Capsicum	5.20 - 5.93
Potatoes	5.40 - 5.90
Pumpkin	4.90 - 5.50
Onions, red	5.30 - 5.80
Ginger	5.60 - 5.90
Carrots	5.88 - 6.40
Cabbage	5.20 - 6.80
Tomatoes	4.30 - 4.90
Beetroot	6.00 – 7.50

Importance of Measurement

The acid formation in fruits is associated with a decrease in pH and this process needs to be monitored by pH analysis. The determination of pH in fruits also has an important role in assigning the correct processing stages for a fruit into the making of preserves or products like jelly or jam. Various canning techniques are available to preserve the seasonal fruits and vegetables based on its pH.

Pickling is another method of preservation for low acid fruits and vegetables. In this case a pH below 4.6 is maintained mostly by adding vinegar, salt etc. The increased acidity level helps to avoid the growth of microbes. The processing and packaging techniques can change the original pH level of pickled products and needs to be monitored closely.

In modified atmosphere packaging (MAP) of fruits and vegetables, the rate of respiration of the packaged food is reduced by lowering the temperature and oxygen levels to maintain taste, texture, and appearance. Scientific literature mentions a decrease of pH in such fruits and vegetables stored under MAP as an indication of lactic acid bacterial growth. These additional processes result in decline of flavor and aroma, affecting the overall quality and freshness of fresh cut or whole fruits and vegetables. Hence, pH measurement can help to study the impact of this preservation technique on the shelf-life.

Measurement Challenges

The solid nature of fruits and vegetables makes it difficult for the electrode to pierce into the sample for direct pH determination. Moreover, interaction of a solid sample with the reference electrolyte is restricted in a ceramic junction based pH sensor and the junctions can easily clog. This affects the overall efficacy and accuracy of pH measurement and the user may experience unstable and erroneous results.

The table below outlines the challenges and negative effects on pH measurement results when using a typical sensor for pH measurement of fruit or vegetable sample.

Sample Challenge	Sample Impact
Solid sample material	Piercing through the sample is difficult with standard shaped pH sensor. Delicate sensing membranes can have abrasions or gel layer can be disturbed during measurement
Sample preparation	Alternate method requires blending the sample into paste for measurement and is time consuming.
Cleaning of sensor after measurement	Sensor fouling due to deposition on the delicate glass membrane, which is difficult to clean. Solid nature of the sample can easily clog the reference (ceramic) junction.

Various sample handling challenges need to be overcome by the user in the case of pH measurement of fruits or vegetables. The delicate gel layer that forms the sensing membranes can be disturbed while trying to pierce through during the measurement process. For this reason, some labs turn to indirect measurement techniques, wherein the sample is blended with water prior to measurement. However, this blending and homogenizing process affects the pH measurement results, yielding inaccuracies while also wasting valuable time. The most accurate method of pH measurement in fruit or vegetables is direct measurement, where the sample is pierced, without the need for blending with water. The direct insertion method also saves time with less scope for errors when compared to alternate methods of blending.

Repetitive pH measurements can foul the sensor membrane due to accumulation of various contaminants that is difficult to wash off properly. This build-up can obstruct the interaction of reference electrolyte and sensor membrane with the sample and lead to delay in pH measurement. A typical ceramic fritted junction gets clogged easily, preventing electrolyte from further mixing with the sample and thereby causing measurement error.

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

Direct Insertion for Reliable pH

InLab Solids Pro-ISM (51344155) is a specialist sensor for measuring the pH of fruits and vegetables with utmost accuracy and precision. The sensor has a built-in temperature probe and provides Intelligent Sensor Management (ISM) technology, allowing users to accurately capture all critical measurement parameters.

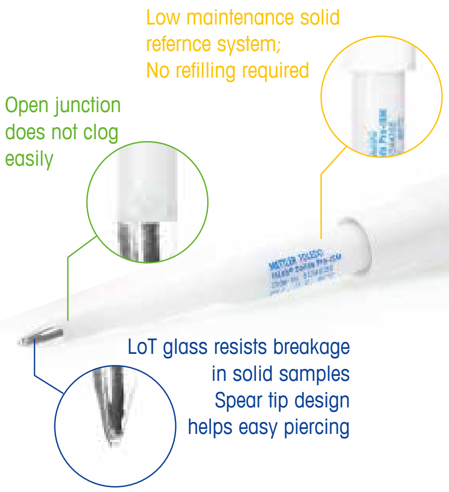

Figure 2: InLab Solids Pro-ISM pH sensor

The spear-shaped tip of this sensor is designed for easy piercing into solid samples. 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 secondly, it has a clog-free open junction, which prevents the risk of sensor fouling. The specialized design and overall sensor technology of the InLab Solids Pro-ISM ensures direct sample measurement of solid fruit and vegetable samples, without the need for undue blending of the sample with water. This direct measurement capability is important for obtaining the most accurate results and ensuring reliability and consistency in the process and quality control in packaging of the final products.

Procedure and Method

A fruit or vegetable slice is cut as a sample for pH measurement. Direct insertion into the fruit is also possible depending on the type. For pickled or canned samples, drain off the brine solution and measure only the pH of the fruit or vegetable directly. If a fruit or vegetable has a hard skin, peel off so as to expose the inner mass. If the fruit or vegetable size is small for direct piercing of pH sensor, blend it into a paste, by adding 10 to 20 ml deionized water for every 100 gm of sample.

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.

Measure the pH of the fruit/ vegetable with InLab Solids Pro-ISM pH sensor by inserting the electrode tip into the sample. Repeat the measurement at various positions to obtain a representative pH reading. The pH sensor has to be inserted such that the sensing membrane and the open junction of the sensor are in contact with sufficient amount of sample. A standard deviation within 0.05 pH units indicates fair variance in the pH measurement of the sample.

Figure 3: InLab Solids Pro-ISM sensor to measure the pH of fruits and vegetables

Application Note

Results

Typical measurement results for fruit and vegetable samples measured in triplicates using InLab Solids Pro-ISM sensor are given in below Table.

Sample	Mean pH Value	Std.Dev.	Avg. time (s)
Apple	4.367	0.04	34
Orange	4.108	0.01	38
Carrot	6.001	0.05	40
Cabbage	6.150	0.03	37
Onion	5.746	0.04	32

Expert Tips

- Clean the electrode after every pH measurement. Contaminated electrode surface leads to slow response of the sensor.
- For thorough cleaning of the residues from the electrode surface after the sample measurement, cleanse it with mild soapy solution, and later rinse it with de-ionized water.
- 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. An old sensor may need frequent conditioning, compared to a new sensor. Remember to re-calibrate the sensor after reconditioning.
- The pH range for this sensor is 1 to 11 pH units and hence should not be exposed to harsh acidic (below pH 1.00) or alkaline (above pH 11.00) solutions.
- 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.
- Ensure use of correct buffers in the correct sequence. Always use fresh buffers. Check expiry date.

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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