

Gas Permeability Testing in Fruit and Vegetable Preservation

Abstract: This article briefs on the methods and mechanisms of preservation and storage of fruits and vegetables.

Keywords: preservation of fruit and vegetable , low temperature , permeability , data fitting

People often focus their attention on the guarantee period when buying food. Guarantee period is a term used for the safety of food. Food within this period can be eaten safely. However, with the improvement of living standard, people have begun to pay close attention to the freshness of food. Therefore, the concept of food preservation comes into being. Food preservation, which has a higher requirement than quality guarantee, refers to that on the basis of safety guarantee, the nutrition, color, texture and flavor can also be guaranteed.

1.preservation of fruit and vegetable

Fruits and vegetables are the most seasonal crops with great demands. A lot of documents point out that, the main reason for loss of fruits and vegetables is the improper storage after plucking. Now, seasonality of fruits and vegetables are becoming less obvious, which is closely related to the general application of preservative technology.

Fruits and vegetables can be stored in many ways. At present the commonly used methods for preservation or quality guarantee are chemical preservation, freeze preservation, vacuum and high temperature sterilization preservation, vacuum and nitrogen-filled preservation, complex modified air preservation and natural bio-preservation.

2.Preservation Theory

The course of storage is mainly influenced by two factors: aerobes and oxidative reaction. Both of them need oxygen gas. Therefore, oxygen gas content of the environment should be reduced to prolong their shelf life or to maintain the quality. But O_2 is essential in the process of package. This is because fruits and vegetables need O_2 for breath after plucking (such as consuming O_2 and producing CO_2), and the anaerobic respiration caused by lacking of O_2 will accelerate their spoilage. To keep the freshness and commercial property of fruits and vegetables to their maximum extent, and to prolong their storage and shelf life, the measure of controlling storage conditions such as the concentrations of humidity, oxygen gas, carbon dioxide and ethylene are recommended. In this way, we can inhibit their respiration and metabolism as well as reduce decaying, plant diseases & pests and loss of moisture.

3.Gas Permeability Testing of Low Temperature Preservative Film

There are mainly three kinds of plastic wraps sold on the market at present: PVDC, PE and PVC. PE is mainly used for fruits and vegetables packaging; PVC and PVDC are mainly used for the package of cold cooked food. Relying on the permeable property of plastic wraps, food preservation is realized by utilizing breath of fruits and vegetables to the maximum extent to reduce O_2 and increase CO_2 (oxygen density cannot be reduced to the extent of anaerobic respiration). In this way, respiration consumption is inhibited by postponing senility.

The application of plastic wrap is closely related to its permeability parameters. Choosing suitable plastic wrap and combining with cold storage is the commonly used preservative method. Whether the permeability is suitable is of vital importance to the cost and quality of preservation. Some fruits and vegetables are cold resistant, whereas some should be protected against coldness. However, the one that can be stored under normal temperature are still rare. The commonly used storage temperature is between 0 °C~ 5 °C . Unless there is special specification, film permeability data are all tested under standard condition (23°C). Since fluctuation of temperature can influence permeability testing remarkably (detailed information can refer to the article named Influence of Temperature Fluctuation on Polymer Permeability updated on January 21st, 2005 in Labthink Forum), permeability of plastic wrap tested under normal temperature cannot represent its permeability in storage environment.

Although the lowest limit of some permeability tester can reach about 0 °C, the state of specimen and instrument will be influenced by low temperature to some extent and operators cannot perform the testing in low temperature environment. Therefore, how to obtain permeability data of plastic wrap in low temperature environment becomes a focus in the field of fruit and vegetable preservation that needs solution urgently.

Now this problem can be easily solved through the data fitting function of Labthink VAC-V1. Data fitting is not a kind of simple mathematic estimation, but a mathematic computational process in which permeability parameters under special temperature is calculated according to the known testing data under normal temperature through data fitting. The advantage of this method is that there is no need performing the test under low temperature and all the data needed for data fitting can be obtained under normal experimental condition. Besides, data fitting is not selective to material. For example, under normal testing environment of 30°C, 35°C, 40°C (these temperatures can be realized and maintained by the automatic temperature control function of VAC-V1), Labthink VAC-V1 is used to test oxygen permeability of PC film with a thickness of 125 µm, the testing data is listed in table 1:

Table1. PC Film Testing Data

Testing Temperature (°C)	O2 Transmission Rate (cm ³ /m ² ·24h·0.1MPa)	O2 Permeability Coefficient (10-11cm ³ ·cm/cm ² ·s·cmHg)
30	608.748	11.59
35	700.118	13.33
40	753.23	14.34

Through data fitting of the above data, O₂ permeability coefficient of 0°C is 5.62×10⁻¹¹cm³·cm/cm²·s·cmHg, and the O₂ transmission rate is 295.441cm³/m²·24h·0.1Mpa. Permeability of 0°C is about two times that of 30 °C. Conduct the data of O₂ transmission rate for PC film between -20°C and 50°C obtained through data fitting in Excel, we can get figure 1, in which the increase rate of PC film permeability gradually slows down with the reducing of temperature.

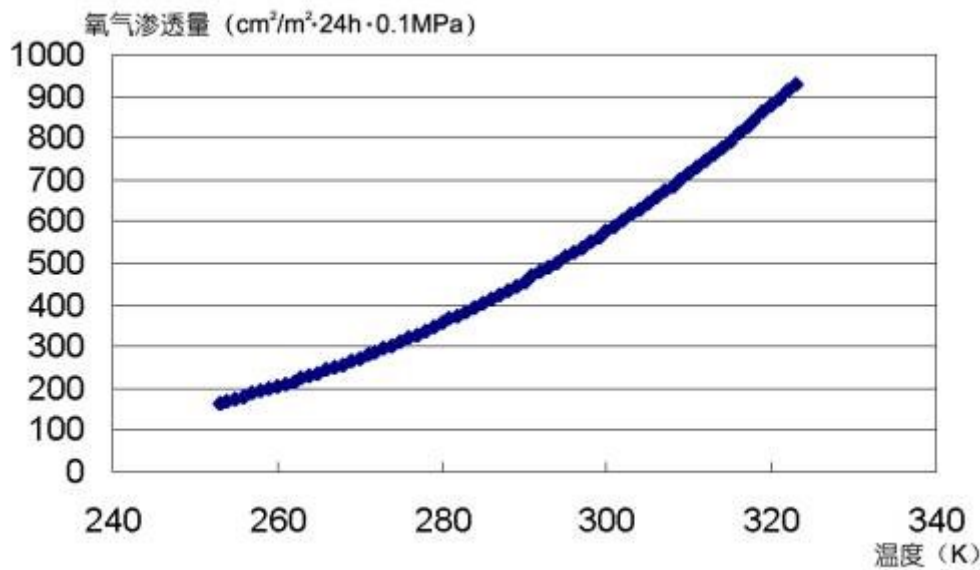


Fig .1 O₂ Transmission Rate and Temperature Curve of PC Film

But it is not always the case that permeability of 0°C is about two times that of 30°C to all kinds of film. For example, test the O₂ transmission rate of film A (unknown material) under 23°C, 30°C, 35°C, 40°C, 45°C with VAC-V1 (detailed data please refer to the article Influence of Temperature Fluctuation on Polymer Permeability). The O₂ permeability coefficient of 0°C calculated through data fitting of the former results is $0.0697 \times 10^{-11} \text{ cm}^3 \cdot \text{cm} / \text{cm}^2 \cdot \text{s} \cdot \text{cmHg}$ and O₂ transmission rate is $5.717 \text{ cm}^3 / \text{m}^2 \cdot 24\text{h} \cdot 0.1\text{Mpa}$. But the O₂ permeability coefficient for film A at 30°C is $0.3150 \times 10^{-11} \text{ cm}^3 \cdot \text{cm} / \text{cm}^2 \cdot \text{s} \cdot \text{cmHg}$ and the O₂ transmission rate is $25.862 \text{ cm}^3 / \text{m}^2 \cdot 24\text{h} \cdot 0.1\text{Mpa}$. As the temperature reduces to 0°C, permeability of film A has improved more than four times comparing with that of 30°C.

With the reducing of temperature, film permeability usually shows a tendency of increase. But the rate of increase is not identical. Some increase quickly, while some are very steady. Therefore guidance only provided by the permeability data under normal temperature is very limited to the overall evaluation of fruits and vegetable preservation.

4.summary

Plastic wrap is one of the commonly used methods in fruit and vegetable preservation. And it is always used combining with low temperature storage. Therefore, obtain the permeability data of plastic wrap under low temperature is very important to the research of preservative mechanism and effect.