Study on the quality change of crown pear during storage

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Abstract: Using the high-quality Crown Pear as the subject of experimental research, an analysis of the changes in the quality of Crown Pears during a storage period is conducted to provide a theoretical basis for the development of the pear cold storage industry. The study utilizes a handheld digital refractometer, texture analyzer, colorimeter, T-type thermocouple, and electronic balance to explore six aspects of Crown Pears: soluble solids content, hardness, color difference, freezing point, drying loss, and taste. The results reveal the following changes in pear quality during different storage periods within one cycle: the content of soluble solids in Crown Pears initially increases and then decreases during the storage period; hardness decreases with increasing storage time; the external appearance of pears gradually darkens; and drying loss increases with storage time. During the cold storage process of Crown Pears, the optimal temperature setting for the cold storage should be maintained at -1°C to 0.5°C. The flavor of Crown Pears is not optimal during the early stage of storage. The storage time for Crown Pears should be within four months.

1. Introduction

The Crown Pear is highly nutritious, with a high polysaccharide content, and contains malic acid, calcium, iron, and various vitamins. It has a crisp and juicy texture and is known for its soothing and cough-relieving effects on the lungs. It holds significant dietary value[1-2]. However, pears are highly susceptible to rot and rapid deterioration, leading to quality loss and fruit softening, which are the most critical factors affecting fruit appearance, texture, flavor, and aroma [3]. Therefore, understanding the quality changes that occur during the storage of Crown Pears is crucial for effectively extending their post-harvest storage time and maintaining good quality [4]. Crown Pears mature in August and are transported to cold storage facilities for storage. Throughout the storage cycle, the quality of pears gradually changes over time. Among them, the hardness, soluble solids content, color difference, and freezing point of Crown Pears all affect their quality and eating experience [5-6].

To ensure that the quality of pears remains consistent with the standards for Crown Pears during the storage process, it is important to understand the changes in pear quality over time. Soluble solids content, hardness, color difference, freezing point, and visual and sensory tests were selected to assess the quality changes in pears [7-8]. Chauvin et al. [9] accurately predicted the hardness characteristics of pears through a two-year "stretch test." Mishra et al. [10] proposed an algorithm to predict the quality changes during pear storage, providing a reference for the timing of pear sales. Pathare et al. [11] studied the increase in color difference and the strong positive correlation of color parameters with increasing storage time, as well as the significant reduction in hardness, providing guidance for the fresh agricultural product supply chain after harvest. Jie et al. [12] measured the freezing point of 11 different fruit varieties using a refractometer and determined the soluble solids content in pears. They compared the different freezing points of different pear varieties and explored the relationship between the freezing point and soluble solids content.

In order to investigate the quality changes of Crown Pears during one storage cycle and provide a theoretical basis for the development of the Crown Pear cold storage industry, this experiment explores the changes in hardness, soluble solids content, freezing point, color difference, and drying loss of Crown Pears with increasing storage time. It will analyze the optimal storage duration and the best time for selling Crown Pears.

2. Materials and methods

2.1 Fruit material

Choosing Crown Pears without mechanical damage and pest infestation from Hebei Longhua Industrial Co., Ltd.'s cold storage facility.

2.2 Principal instrument

The equipment used in the experiment is shown in Figure 1: a texture analyzer, a handheld digital refractometer from ATAGO (model: ATAGO), a colorimeter model "CR-400" from Konica Minolta, a data collector and T-type thermocouple (with an accuracy of 0.1°C), and an electronic

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balance model YP50001 from Shanghai Yueping Scientific Instrument Co., Ltd. (with an accuracy of 0.01g).

Fig.1 Test equipment

2.3 Experimental design

After cooling and stable storage in the cold storage facility, the pears are transported via cold chain to the variable temperature storage facility at Tianjin University of Commerce, School of Mechanical Engineering. The temperature is controlled within the range of -0.3 to +0.3°C, with a humidity of 90% to simulate the cold storage environment for pear storage. The changes in pear quality over time are monitored under these conditions. The quality changes of pears under simulated environment and some quality indexes of cold storage pears were compared by variance analysis. Crown Pear Hardness: Five Crown Pears are selected as test samples each time. Three points are chosen near the equator of the pear, and the probe of the texture analyzer, set at P/5, is aligned vertically with the pear's surface. The probe advancement speed and distance are set, and the hardness measurement data are read from the texture analyzer software. After the measurement is completed, the probe is removed, wiped clean, and returned to its original position.

Soluble Solids Content: The digital refractometer is zero-calibrated using distilled water. Five pears are selected for each experiment, and each pear is divided into three parts. The flesh of each portion is cut into small pieces and juiced for the measurement of soluble solids content. The measurement data are recorded, and after the measurement is completed, the equipment lens is rinsed with distilled water and dried with absorbent paper.

Color Difference: The external appearance of the pears is measured. Prior to each test, the colorimeter is calibrated using a whiteboard. Five pears are selected and labeled, and three different positions on each pear are measured using the colorimeter. The data are recorded.

Freezing Point: Five pears are placed in a -10°C refrigerator, and a thermocouple temperature probe is inserted into the flesh of the pears. The temperature recorder is set to record data every 5 seconds until the temperature reaches -5°C.

Drying Loss: Two packaging methods are used, with 40 pears placed in each type of packaging. The initial weight is recorded, and the pears are stored in the same cold storage facility for three months. After the storage period, the pears are weighed again and compared to the initial weight.

Visual and Sensory Testing: A sensory testing table is prepared, and a group of participants who can consistently and reliably participate in the testing are recruited. Eight participants take part in each round of testing, and after multiple tests, the data from each individual are compared longitudinally. The appearance and taste changes are analyzed through the scores given by the participants.

3. Results and discussion

3.1 Crown pear hardness analysis

The Crown Pear, also known as the Golden Pear, has an appropriate fruit hardness standard for edible purposes ranging from 5.0 to 8.0 (kg/cm^2). Hardness is largely determined by the physical anatomy of the tissue (in particular, the size and shape of the cells, the thickness and strength of the cell wall)[13]. When freshly harvested and stored, Crown Pears are not fully ripe, and their cell walls contain a significant amount of protopectin and starch, which are insoluble in water, resulting in a firm texture. After a period of storage, pectinase enzymes break down the protopectin into soluble pectin. Along with the process of saccharification, substances such as starch begin to convert into sugars, leading to a decrease in fruit hardness. Over time, Crown Pears gradually ripen and lose water, resulting in a looser arrangement of cells. The starch is gradually consumed, and sugars start to break down through respiration. At this stage, the hardness of the pears further decreases. The change in hardness is illustrated in Figure 2, showing that the hardness of Crown Pears decreases with increasing storage time. In actual storage conditions, the rate of hardness change in Crown Pears is faster than in the controlled cold storage environment. Experimental evidence confirms that a simulated environment with high-precision temperature control can extend the storage period for pears.

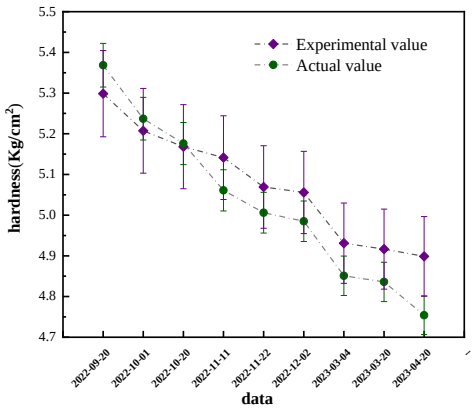

Fig.2. Changes in hardness of yellow crown pear during the storage period

3.2 Soluble solid content

Soluble solids in pears mainly refer to sugars, organic acids and other compounds dissolved in water, which dissolve in the fruit juice to form a solution. According to the national standard, the soluble solid content of the most suitable pear is about 12%. The variation in soluble solids content with storage time is shown in Figure 3, indicating an initial increase followed by a decrease. This is because crown pears initially contain a large amount of insoluble substances: starch. During the storage process, starch is continuously converted into soluble solids, leading to an increase in the soluble solids content until complete conversion of starch occurs. Before complete conversion, the soluble solids content undergoes slight fluctuations due to the combined effect of starch conversion and respiration. After the starch is completely converted into soluble solids, the pear continues to undergo respiration, resulting in the consumption of soluble sugars within the fruit and a subsequent decrease in the soluble solids content. Comparing the changes in the simulated cold storage environment with those in the actual cold storage facility, it can be observed that the variation in the simulated environment is slower than in the actual storage, indicating a slower reduction in soluble solids content after ripening. This suggests that the pears can be stored for a longer period, making high-precision temperature control more beneficial for pear storage. Soluble solids content is a major nutritional component of pears and an important indicator of their sweetness and taste. It significantly affects the quality of pears, and therefore, attention should be paid to the soluble solids content at the time of release to ensure the desired taste of the pears.

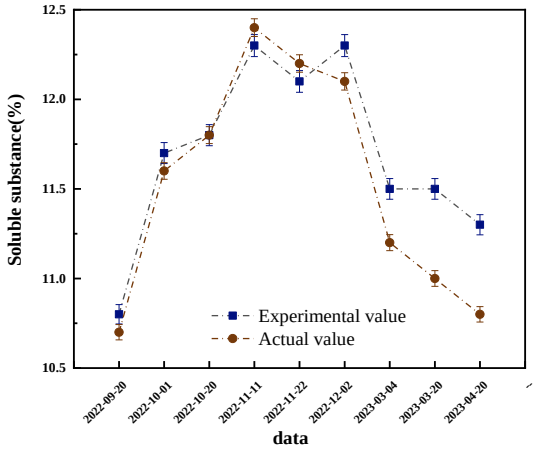

Fig.3. Changes in soluble solid content in Huangguan pear during the storage period

3.3 Chromatic change

The appearance and color are important indicators for differentiating the quality grades of Crown Pears. A colorimeter is used to measure the pear's skin. In the colorimeter, the "L" value represents the lightness from black to white, ranging from 0 to 100. A higher L value indicates a brighter and whiter color, while a lower L value indicates a darker color. The positive or negative value of "B" represents the color between yellow and blue. A positive B value indicates a yellowish hue, while a negative B value indicates a bluish hue. A high-quality Crown Pear has a light yellow color with translucent white flesh. An immature Crown Pear has a higher green color index and a lower yellow color index. As the Crown Pear ripens, the yellow color index increases, the green color index decreases, and the brightness increases. With increasing storage time, the yellow color index continues to increase, the green color index decreases, and the color becomes darker. The changes in the L and B indexes of the pear after ripening are shown in Figure 4. The pear has the highest luster when it has just ripened, but the color may slightly darken in the later stages of storage. The color of the pear deepens with increasing storage time. The pear contains a certain amount of iron, which exists in the + 2-valent ion state, + 2-valent iron shows light green, with the growth of the storage time of the crown pear, the oxidation continues, when the skin is rubbed or squeezed, the + 2-valent iron in the pear comes into contact with the air (containing oxygen and other oxidizing substances). It is oxidized to +3 iron (+3 iron is reddish-brown), so as more +2 iron is oxidized, the color slowly darkens. Comparing the changes in the simulated cold storage environment with those in the actual cold storage facility, it can be observed that the color changes in the simulated environment are slower than in actual storage. In the later stages of storage, the simulated environment pears have L and B indexes approximately 4% and 6% higher, respectively, compared to the pears in the actual cold storage facility. High-precision temperature control can also slow down color changes, which is beneficial for storage.

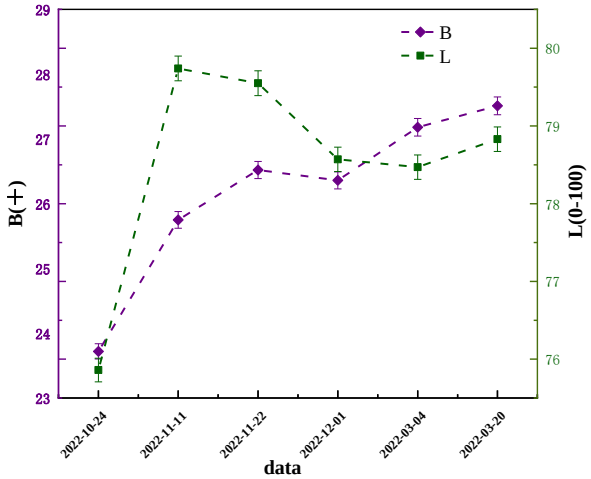

Fig.4. Changes in soluble solid content in Huangguan pear during the storage period

3.4 Dry consumption analysis

The weight loss of fruit is due to the transpiration process, which is usually determined by the water vapor pressure gradient between the fruit and the surrounding air. Drying loss, also known as weight loss, is the phenomenon of a decrease in food quality due to moisture evaporation during storage. It can be divided into absolute drying loss and relative drying loss. Absolute drying loss refers to the pure

mass loss of the food. Relative drying loss refers to the ratio of the reduced mass to the initial mass of the food. Excessive relative drying loss can cause wrinkling and wilting of the fruit skin. When the relative drying loss of fruits and vegetables reaches 5%, wilting becomes noticeable. In the experiment, 40 pears were stored under the same conditions in both plastic baskets and perforated paper cartons for two months, from October 13, 2022, to December 14, 2022. The weight changes were measured to investigate the drying loss, as shown in Table 1. This can be clearly seen in Figure 5: Pears packed in perforated PVC bags inside perforated paper cartons showed lower relative drying loss, indicating that this packaging method is more favorable for storage. Although the cost is low, the main material of the plastic film is polyethylene, and the gas permeability is low. If the humidity in the bag is too large and the oxygen content is too low, it will cause the fruits and vegetables to breathe without oxygen, produce a lot of alcohol, which will cause bacteria to breed, and greatly reduce the safety and nutritional value of fruits and vegetables. And the plastic film has a certain light transmission, aggravate the fruit photosynthesis. It is easy to lead to less fruit water and poor fruit hardness; Although the cost of fruit packaged in paper bags is slightly higher, it can maintain better storage quality in storage.

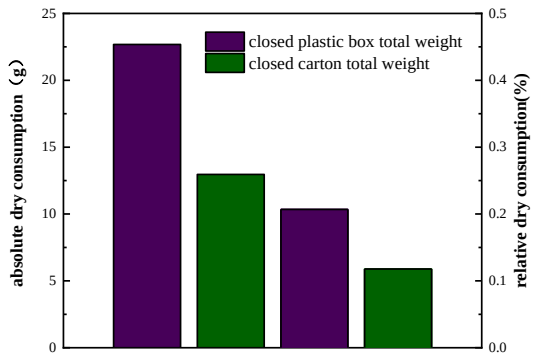

Fig.5. The difference of dry consumption of different packaging crown pears during storage

Table 1. Key parameters of crown pear weight

data	closed carton total weight (g)	closed plastic box total weight (g)
2022-10-13	11010.68	10958.20
2022-12-14	10997.72	10935.52

3.5 Freezing point change analysis

During the actual storage process, the temperature in the cold storage facility should not be lower than the freezing point of the pear at any position and at any time. This is because if freezing occurs at any position of the fruit, the entire fruit will spoil and cannot be sold. As shown in Figure 6, the freezing point of the pear decreases initially and then increases with increasing storage time. From September to December, the freezing point of the pear continues to decrease. This is because during ripening and storage, water molecules may spread outward from the fruit's cells, which causes the fruit's cells to condense. When the concentration of solutes (such as sugars, minerals, and organic acids) inside the pear increases, these solutes form more hydrogen and ionic bonds in the water, thereby lowering the freezing point of the water. This phenomenon is known as hypofreezing. It was observed that during this period, the soluble solids content of the pear increased. There is a certain correlation between the freezing point and the soluble solids content of the pear. The freezing point of the pear decreases with an increase in the soluble solids content. This may be because the reduced free water content between tissues makes it difficult for ice to form. The correlation between the freezing point and soluble solids content of the pear is shown in Figure 7, the result shows that the soluble solids are highly negatively correlated with the freezing point, and the conclusion is consistent with the law in reference 12.

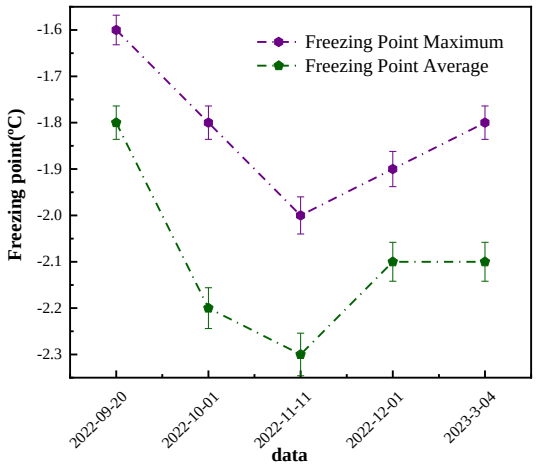

Fig.6. Changes in freezing point of Huangguan pear during storage

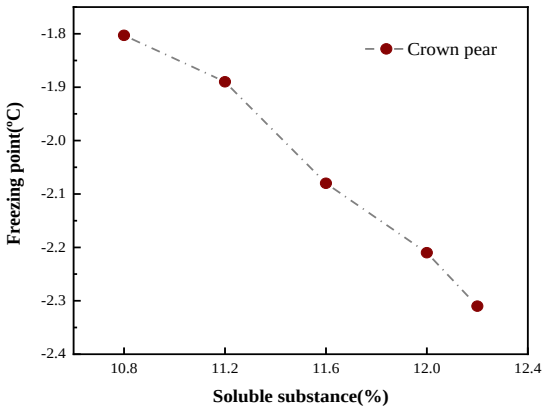

Fig.7. Relationship between the freezing point and soluble solid content

3.6 Taste test

Sensory analysis is related to fruit consumption. The sensory evaluation form includes scoring criteria such as color, appearance damage, sweetness, juiciness, acidity, hardness, and overall taste. Due to variations in individual judgment and differences between pear samples, it is necessary to have the same group of evaluators for each assessment. Their scores are then compiled and processed to

create a chart depicting the changes in pear taste over storage time, as shown in Figure 8. The taste scores of the pear gradually increase until November and December, reaching their peak. Afterward, the scores start to decrease.

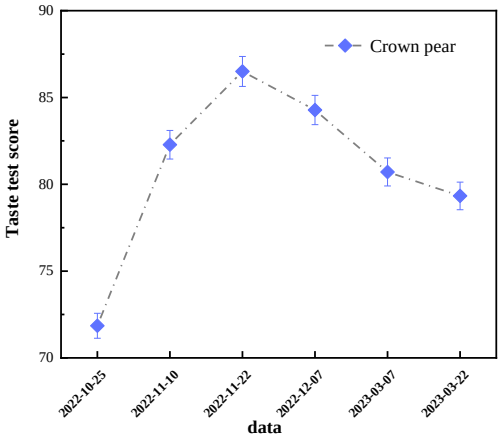

Fig.8. Changes in taste score of Huangguan pear during storage

4. Conclusion

(1) The hardness of the Crown Pear decreases with increasing storage time and reaches its optimal edible state in November and December, with a hardness of approximately 5 kg/cm2.

(2) The soluble solids content of the Crown Pear shows an increasing trend initially and then decreases with increasing storage time. The best performance is observed within a two-month storage period.

(3) The color difference of the Crown Pear increases with increasing storage time, with the yellow index continuously increasing and the green index decreasing. Paper carton packaging exhibits lower relative drying loss compared to plastic packaging, making it more suitable as a packaging material.

(5) During the storage of the Crown Pear, the freezing point should not be lower than -2.3°C. The freezing point decreases with an increase in the soluble solids content.

(6) Based on the comprehensive exploration of pear quality, it is not advisable to sell the pears too early as they are not fully ripe, have low soluble solids content, high hardness, and poor taste, resulting in lower prices and unfavorable sales. In November and December, when the pears are ripe and have good quality and taste, selling them can receive positive feedback from consumers and promote subsequent sales of Crown Pears.

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