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Effect of temperature control and high humidity on the preservation of JUFENG grapes

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A b s t r a c t. The biochemical changes of JUFENG grapes of various degrees of maturity during controlled-temperature-and-high-humidity (CTHH) preservation were analyzed through tests. The rule changes for soluble solids content, reductive sugar, acid content, respiratory quotient (RQ) and resistance to pressure during storage were studied. Methods of removal from storage were tested. In order to ensure the quality and shelf-life of the grapes, a method to remove the grapes from storage in three separate stages after CTHH preservation was adopted.The preservation of the grapes of different maturity degrees under CTHH conditions shows that there was a small change in texture, chemical composition, respiratory quotient, weight and decomposition rate, demonstrating good storage practice. The CTHH technique is a really useful method for preserving freshness.

K e y w o rd s: grapes, preservation, controlled-temperature-and-high-humidity, maturity degree, out-store test

INTRODUCTION

The grape is a cash crop with good agricultural characteristics. It is one of the most important fruits in China [4]. Following improvement in the living standards of the people, the demand for fresh grapes is on the increase [1], but due to their soft texture and high water content, the fruit easily deteriorates [2]. Under normal local atmospheric conditions, grapes can be stored for only 2–3 days [6]. So the preservation of grapes is of great concern.

The traditional methods for preserving grapes are basket-storage, jar-storage, cellar-storage and chemical storage. Most of the storage methods can be effective at low temperatures, but it is not easy to control temperature with precision and maintain high humidity. It is well known that any variation in temperature affects respiration and metabolism. Humidity is generally low and can cause water loss of about 10–13%. Therefore, traditional cold storage cannot efficiently preserve freshness [3].

In southern China, preservation time for the grape is only 7–10 days depending on the variety and climate. Most grapes have their freezing point between –1.3 and –1.6 C. Many researchers have shown that a drop in physiological activity is observed in frozen grapes while metabolism is maintained at normal levels. This is beneficial for extending the preservation time and avoiding decomposition or damage occasioned by the chilling process [6]. CTHH preservation has two advantages. Firstly, destruction of the fruit's texture is avoided because no ice-crystals are formed under 0 C ice-temperature conditions and secondly, the high humidity used prevents the fruit from dehydration. Compared with normal cold preservation, CTHH can efficiently prevent decomposition, dehydration, ice-formation and the destruction of texture and therefore extend shelf-life [8].

The preservative effect is also related to the degree of maturity [9]. It is generally considered that ripe grapes are easy to preserve because of their high sugar content and thicker skin. In this paper, physiological and texture changes during CTHH preservation were monitored on JUFENG grapes and the method of removal from storage was tested.

MATERIALS AND METHODS

Materials

Grapes were obtained from the Modern Agricultural Garden of Liyuan Township of Wuxi City. The maturity degrees of the grapes tested were about 5–6, 7–8 and 8–9, respectively. The definition of the degree of maturity was given according to the change of sugar and acid in the fruit [2]. The degree of maturity was also identified visually by the planter. The color difference for grapes of different maturity was: 1) for 5–6 degree of maturity, the color of the

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grape was half purple and half green; 2) for 7–8 degree of maturity, most parts of the grape were purple, but the smaller parts were green; 3) for 9–10 degree of maturity, the whole grape was purple.

Equipment and experimental methods

Equipment

The CTHH equipment (Fig. 1), an Instron Texture Testing Equipment, a pH determination apparatus, and a tissue triturate apparatus were used in the research.

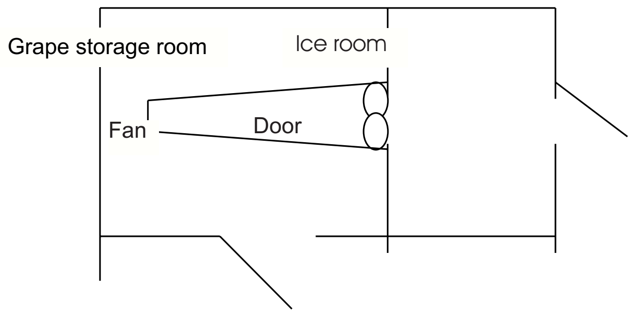

Fig. 1. CTHH (0 C) equipment.

Preparation of the experiment

Ice blocks and salt were mixed in a ratio of 100:2 and placed in the insulation layer of CTHH equipment. During the experiment, ice was added to maintain the temperature at –1 to 0 C and the humidity above 95%. The grapes were pre-refrigerated to about 0 C, weighed and stored in prepared experimental conditions. The samples were evaluated periodically and the results analyzed against a control sample to determine the effect of CTHH on the grapes.

'Removal from storage' experiments

JUFENG grapes which had been preserved in the CTHH equipment were taken out of the store room in three ways: 1) Method A: Removal from storage was divided into three steps 0 10 20 C room temperature (about 26 C; 2) Method B: Removal from storage was divided into two steps 0 20 C room temperature; 3) Method C: Removal from storage was carried out directly 0 C room temperature.

When the temperature of the materials were at room temperature, the analysis was conducted.

Method of analysis

The determination of respiratory intensity is by the static method. The determination of reductive sugar is by the Folin method [5]. The total acid measurement depends on the acid-base titration method. The soluble solids content measurement is by the refraction method. The decomposition rate can be calculated by the weight of the decomposed grape over total weight. Resistance to pressure can be measured by the Instron Texture Testing Equipment. The velocity of the pressure sensor, whose diameter is 15 mm, is 50 mm per minute.

RESULTS AND DISCUSSION

Changes in weight loss

The weight loss of JUFENG grapes with three degrees of maturity is shown in Table 1. The results show that in CTHH preservation, the weight loss is nearly zero. This is mainly because of the high humidity of the water concentrated on the surface of the grapes. In normal preservation, weight loss is due to the consumption of substance through respiration but dehydration through evaporation remains the main reason. When weight loss reaches 5%, this obviously determines freshness. The expansion pressure of grape cells will drop and even disappear because of weight loss, and fresh grapes will shrivel.

Decomposition rate

During storage, the decomposition rate of the three degrees of maturity is shown in Table 2. Highly mature grapes (9–10) decompose and drop easily, grapes with a 5–6 degree of maturity drop easily, while grapes with a 7–8 degree of maturity store well.

Table 1. The change of weight-loss rate during the ITHH storage (%)

Maturity degree	Storage time (d)						
	0	10	20	30	40	50	60
5–6	0.0	0.0	0.3	0.4	0.4	0.5	0.6
7–8	0.0	–0.2	–0.2	–0.2	–0.3	–0.3	–0.3
9–10	0.0	–0.1	–0.1	–0.2	–0.2	–0.2	–0.2

T a b l e 2. The change of putrid rate during the ITHH storage (%)

Maturity degree	Storage time (d)						
	0	10	20	30	40	50	60
5–6	0	0.3	1.4	4.5	8.5	13.1	19.7
7–8	0	0.6	1.5	3.0	3.5	5.2	6.3
9–10	0	2.8	18.7	28.9	36.3	41.2	49.4

Respiratory quotient

The respiratory quotient of JUFENG grapes at the third degree of maturity during storage is shown in Fig. 2. The grape belongs to the family of fruits without breath-mutation. Its respiratory quotient tends to decline slowly. When the temperature is stable and low, the grape has a low respiratory quotient. All of these will be beneficial to the grape's long-term storage. Grapes with a 5–6 maturity degree have a high respiratory quotient in the early storage periods.This shows that the grape is still metabolizing, while grapes with a 9–10 degree of maturity have a high respiratory quotient in the later storage periods. The grape can be seen to be in a state of decomposition.

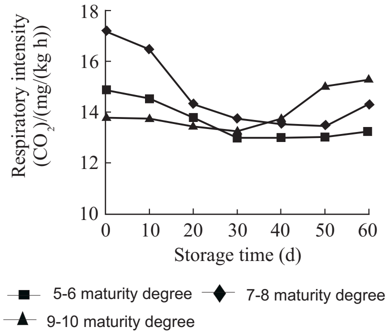

Fig. 2. The change of respiratory intensity during the ITHH storage.

Texture deterioration

Texture change is monitored mainly by resistance at the pressing stage. The change of resistance during CTHH storage is shown in Fig. 3. This tends to decrease slowly in general because at the initial stage of preservation, protopectin, the main pectic substance in grapes, is closely associated with the cell wall cellulose. Also the high water content in grapes increases expansion pressure in the cells and the firmness of the fruit and consequently, resistance to pressure. During storage, protopectin is transformed into pectin by the action of pectinases and separated from the cell wall. The texture therefore becomes soft. If the transformation were to go on to the pectic acid formation stage, the texture would soften and the fruit would rot, losing edibility and commercial value. Moreover, resistance to pressure increased when the degree of maturity decreased. Grapes with a lower maturity degree had a lower resistance to pressure. This proved that the grapes were young.

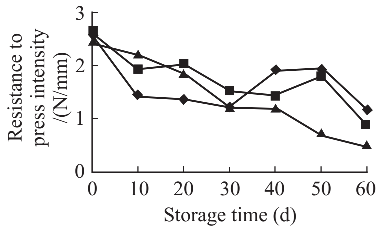

Fig. 3. The change of resistance during the CTHH storage. Explanations as in Fig. 2.

Principal chemical compounds

Table 3 shows the variation in soluble solids, reductive sugar and acidity of grapes with different degrees of maturity in CTHH storage. The change in the solids' acidity rate during CTHH storage was shown in Fig. 4. Accumulation of substance ends with the harvest of grapes; metabolism consists essentially of decomposition. At that time, the lower the changes in chemical composition, the slower the decay and decomposition and the more efficient the preservation and corresponding shelf-life is extended. Reductive sugar and acid decreased slowly during storage, and the corresponding solid acid ratio decreased slowly. This proved the efficiency of the preservation. Grapes with a low maturity degree increased rapidly while the acid decreased rapidly in the early preservation. Moreover, total sugar and solid-acid are correspondingly low.

The effect of the 'removal from storage' method on shelf-life during CTHH storage

The change of resistance to pressure after removal from storage is shown in Fig. 5. The change in respiratory intensity after removal from storage is shown in Fig. 6. The

T a b l e 3. The change of principal chemical component during the ITHH storage (%)

Storage time (d)	Mass percent of reductive sugar (%)			Mass percent of solids (%)			Mass percent of acids (%)		
	5–6*	7–8	9–10	5–6	7–8	9–10	5–6	7–8	9–10
0	9.44	11.86	12.19	11.2	13.5	12.9	0.97	0.73	0.68
10	9.57	11.61	11.94	12.2	13.4	13.4	0.81	0.69	0.64
20	10.89	11.52	12.05	13.1	13.8	13.3	0.77	0.65	0.63
30	10.67	11.25	11.64	13.5	14.1	14.0	0.76	0.62	0.61
40	10.38	10.87	11.53	13.3	13.5	12.9	0.72	0.62	0.59
50	10.48	10.04	10.96	13.6	13.4	13.2	0.69	0.61	0.60
60	10.55	10.67	11.30	13.5	13.2	13.4	0.70	0.58	0.59

Note* is behalf for the grape's maturity degree.

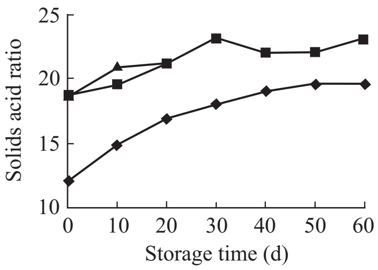

Fig. 4. The change of solids acid during the ITHH storage. Explanations as in Fig. 2.

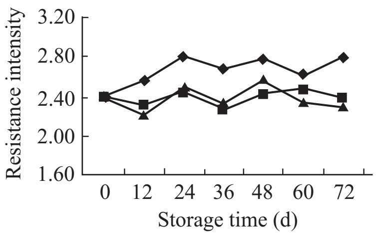

Fig. 5. The change of resistance after out storage. Explanations as in Fig. 2.

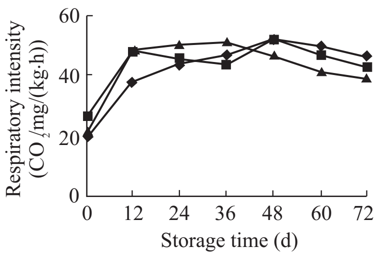

Fig. 6. The hange of respiratory intensity after out-storage. Explanations as in Fig. 2.

putrefaction rate – 4 days after having been removed from storage is shown in Table 4. If the grape is put into a higher room temperature immediately after CTHH storage, several different bio-chemistry reactions correspondingly hasten any changes because of the sharp temperature alteration. Water accumulating on the surface of the grapes provides beneficial conditions for microorganisms to reproduce. Thus the quality of the grape is damaged and the shelf-life is shortened; however, grapes have a good quality shelf-life after having been removed from storage in three stages. These grapes have stable resistance to pressure, a low and stable respiratory quotient and the rate of decomposition is very low during shelf-life.

T a b l e 4. The putrid rate after 4 days out-storage

Out-storage style	Putrid percent (%)
A (three-step transition)	7.8
B (two-step transition)	9.3
C (direct out-store)	11.9

CONCLUSIONS

1. The preservation of grapes with different degrees of maturity under CTHH conditions shows that there is a small change in texture, chemical composition, respiratory quotient, weight and decomposition rate, which shows good storage practice. The CTHH technique is a really useful method for the preservation of freshness. It overcomes short shelf-life and avoids the deterioration in texture seen in frozen storage. CTHH preservation is a practical method for the preservation of freshness.

2. The degree of maturity has an important bearing on the effect of preservation. Grapes with a 7–8 degree of maturity have the best effect.

3. In order to ensure the quality and shelf-life of the grape, a three-stage period where the grapes are not stored should be adopted after CTHH preservation.

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