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Preservation of fresh grapes at ice-temperature-high-humidity

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A b s t r a c t. Biochemical changes in grapes during the ice-temperature-high-humidity (ITHH) preservation were analyzed through tests. The rules of changes in the content of soluble solids, reductive sugar, total acid, respiratory intensity and press resistance during storage test were studied. The causes of those changes and the relation among them were analyzed. The results showed that changes in grapes during 60 days of ITHH preservation were small, and there is not any distinct difference in texture and flavour between the tested grapes and fresh grapes, so that the ITHH preservation is a prefered method.

K e y w o r d s: grapes, preservation, ice-temperature-high-humidity

INTRODUCTION

Grape is one of the most important fruit in China. It is an economic plant with good agricultural characteristics. National annual output occupies a leading position in the world fruit production (Peng, 1994; Yang, 1996). Grape is mainly processed into juice, wine or raisin. The amount of grape that goes for sale as fresh fruit for direct consumption accounts for a very low percentage of the total production and only little quantities are found on the market out of season (Yang, 1996).

Following the improvement in the living standard, the demand for fresh grape is increasing but, due to their soft texture and the high water content, the fruit easily undergoes deterioration, which makes it very difficult to preserve. Under normal local atmospheric conditions, grapes can be stored for only 2~3 days (Shang, 1995). In order to ensure even distribution in time and in space, preservation of grapes is of great concern.

Traditional methods of preserving grapes are basket-storage, jar-storage, cellar-storage, chemical storage and, cold storage which is the most commonly used method. Most of the storage methods can be effective when practised at low temperature (Peng, 1994), but it is not easy to control tempe rature with precision and maintain high humidity. It is well known that variation of temperature affects respiration and metabolism and, consequently, preservation. Under normal cold storage of grapes, rot rate can reach 25~30%. Also, in the normal cold storage, humidity is generally around 80% which appears to be low and can cause water loss of about 10~13% while 5% water-loss in fruit during storage generally leads to witherness and wrinkleness. Therefore, traditional cold storage cannot efficiently fulfill the objective preserving fresh (Fennema, 1991).

The freezing point varies with different types of grape. Most grapes have their freezing point between -1.3 ~ -1.6°C. A lot of research work showed that, a drop in the physiological activity is observed in the frozen grapes while the metabolism is maintained at a normal level. This is beneficial for extending preservation time and avoiding rotting or chilly injury. The ice-temperature-high-humidity (ITHH) preservation has two advantages, i.e.: 1) destruction of the fruit texture is avoided because there is no ice-crystal formed under the 0°C ice-temperature and 2) high humidity prevents the fruit from dehydration. Compared to the normal cold preservation, ITHH can efficiently prevent rotting, dehydration, ice-formation and destruction of texture, and therefore extend the shelf-life. This has received great attention in the recent years (Liu, 1988; Sun, 1986; Li, 1991). In the cold northern area of China, the ITHH method is applied to save energy while in the central and southern areas, it aims at the preservation of valuable fruit and vegetables. In the present work, the physiological and textural changes during ITHH preservation were monitored on Tengren and European No. 5 grape varieties.

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MATERIALS AND METHODS

Material and equipment

Grapes were picked up from the Modern Agricultural Garden of Liyuan Township of Wuxi city. Except where specified, the degree of ripening is about 90%. ITHH equipment made by the present authors is shown in Fig. 1.

The size of the ITHH equipment is 1.1 0.5 1.4 m. Expanded polystyrene (EPS) was used for the insulation layer 10 cm thick.

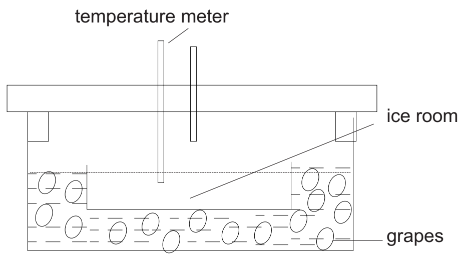

Fig. 1. The ITHH equipment.

Experimental method

Ice block and salt are mixed in the ratio 100:2 and placed in the insulation layer of ITHH equipment. During the experiment, ice is added to maintain the temperature at -1~0°C and the humidity above 95% (Tao, 1999). Grapes are prerefrigerated to about 0°C, weighed and stored in the prepared experimental condition. The samples are evaluated periodically and the results are analyzed against a control sample to determine the effect of ITHH on grapes.

Methods of analysis

Determination of respiratory intensity is by the static method (Huang, 1989). Determination of reductive sugar is by the Folins method (Huang and Yang, 1992). Total acidity measurement depends on the acid-base titration method (Huang and Yang, 1992). Soluble solid content is measured by the refraction method (Huang, 1989). Rotting rate can be calculated by the weight of rotten grapes over total weight. Weight-loss can be calculated by the ratio of periodic weight to the initial weight. Grape structure changes after pressing can be measured by an Instron texture testing equipment. Moving velocity of the pressure sensor with a diameter of 15 mm, is 50 mm per minute. Three indices for the grape structure changes used in the paper were pressure tolerance, deformation and resistance to pressure (RP). Pressure tolerance means the maximum pressure on the grapes does not cause raptures. Deformation means axial changes of the grapes when rupturing. Resistance to pressure means the maximum intensity of pressure on grapes to maintain their skin continuity.

RESULTS AND DISCUSSION

Changes in the respiratory intensity

Like any other fruit, grapes are still living organs after harvest. It is then necessary to maintain their respiration intensity at a suitable level in order to keep the fruit fresh. After harvest, there is no more accumulation. Some of the accumulated matters are gradually consumed in the respiration to provide the living organs with energy, some take part in different forms of transformation, dissociation and recomposition. Consequently, grapes go through ripening to senescence. High respiratory intensity will lead to the consumption of the nutrients accumulated in the grape tissue, accelerating ripening process and reducing the shelf-life. But with lower respiration intensity, the shelf-life is prolonged (Liu, 1988; SCAC, 1981). Figure 2 shows changes in the respiration intensity during storage.

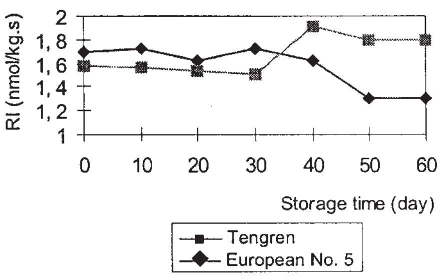

Fig. 2. The respiratory intensity changes during fresh storage.

Grapes, belonging to the family of fruit without breath-mutation, do not have a distinct after-ripening stage. It is shown the results on the respiration intensity of Tengren grape that tends to decline within 60 days of storage but the drop is really insignificant. During the first 40 days especially, there is almost no variation. The initial respiration intensity (RI) was 1.70 mg $(kg\ h)^{-1}$, but it was 1.62 mg $(kg\ h)^{-1}$ after 40 days and 1.31 mg $(kg\ h)^{-1}$ after 60 days. During the after-ripening stage, thickness of the protective layer of epidermis, wax and cuticle increases, intracellular gaps narrow (down). There is also a decrease of gas exchange, concentration of CO_2 in the tissue rises while O_2 concentration decreases, leading to a gradual decreasing trend observed for the RI. Since temperature is adjusted to the freezing point and kept constant, there is little variation of the RI, the absolute value of the RI is therefore very low (Liu, 1988; Peng, 1994). In this work, the RI was controlled to a very low level, its variation was also not significant. An increase in the rotting rate in the 60 days of fresh storage was as low as 6.9% (Fig. 3). This indicates that Tengren grapes, during 60 days of storage under ITHH conditions, can maintain a very low rate of metabolism, a slow after-ripening activity to ensure a long shelf-life.

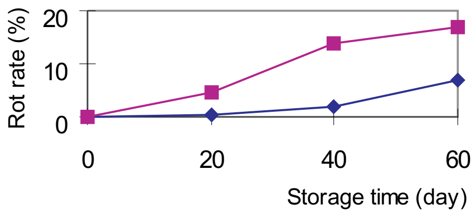

Fig. 3. The rot rate changes during fresh storage. Legend as in Fig. 2.

In the case of the European No. 5 grape, during the first 40 days of storage, the RI was also very low, but the rotting rate increased rapidly to reach 13.7% and was over 17% at the 60th day. It implies that this type of grapes does not resist storage. The RI increased considerable after 40 days from 1.51 to 1.79 mg $(kg\ h)^{-1}$. This can be explained by the high rotting rate which might lead to the fermentation process.

Changes in chemical compounds during storage

Changes in the chemical composition constitute one of the most important factors in evaluating the effect of fresh preservation. Accumulation of substance ends with the grape harvest, metabolism consists essentially of decomposition (Liu, 1988; SCAC, 1981). At that time, the lower the changes in the chemical composition, the slower decay and rotting, the more efficient preservation and the corresponding shelf-life is extended. Figure 4 shows variations in soluble solids, reductive sugar, acid and sugar-acid ratio. It appears from the results, that the ITHH conditions can control the RI to a very low level, this is very useful for extending the shelf-life in fresh storage.

During storage, reductive sugar shows a little increase at first, then it decreases gradually, but the variation is not significant. For the Tengren grape for instance, reductive sugar increased from the initial value of 10.90% to the maximum of 11.73%, then dropped to 11.0% at the end of the test period. Changes in the reductive sugar of the European No. 5 were as follows: 10.70 - 12.92 - 9.81%. The variations can be explained by the hydrolysis of carbohydrates leading to an increase in the reductive sugar on one hand, and on the other hand, to a continuous respiratory activity consuming low molecular weight of reductive sugar followed by the drop observed at the end. The smaller this variation, the slower the after-ripening process and the longer the shelf-life.

Total acid content also affects the quality of grapes. During storage, consumption of organic acid as a substrate for respiration leads to a decrease in the acid content (Liu, 1988). The acid content for the two kinds of grapes decreased, respectively, from 0.63 and 0.49 to 0.58 and 0.41%. Changes in the sugar acid content resulted in the variation of sugar/acid ratio as observed in Fig. 4d.

From the results above, it appears that the Tengren is a variety of grapes suitable for the ITHH storage, there is little variation in the reductive sugar and acid; resistance of the European No. 5 to preservation is somewhat poorer.

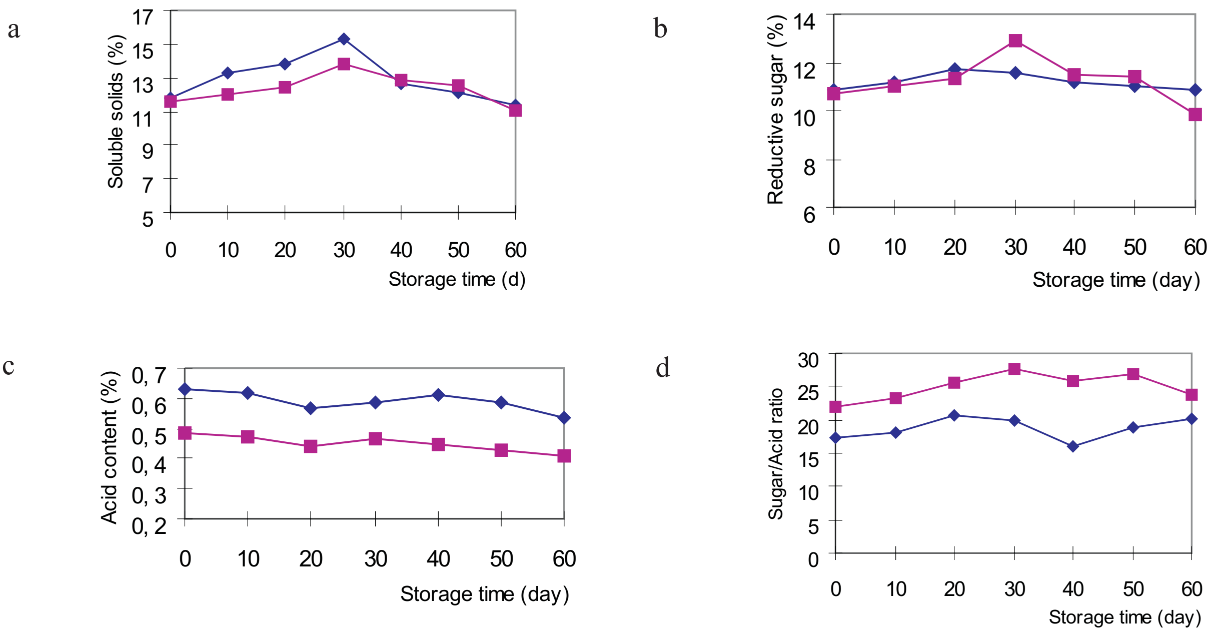

Fig. 4. Changes in soluble solids (a), reductive sugar (b), acid content (c), and sugar/acid ratio (d) during preservation. Legend as in Fig. 2.

Weight loss and texture deterioration during preservation

Weight losses during storage are shown in Fig. 5. Weight loss is due to the consumption of substances through respiration, however dehydration through evaporation remains the main reason. Under strict condition fruit and vegetable can maintain normal metabolism, then water loss is the most important factor determining their freshness. In the present test, the water loss rate is very low because humidity is kept high. The water loss in the two types of grapes is 2.7 and 4.4%, respectively.

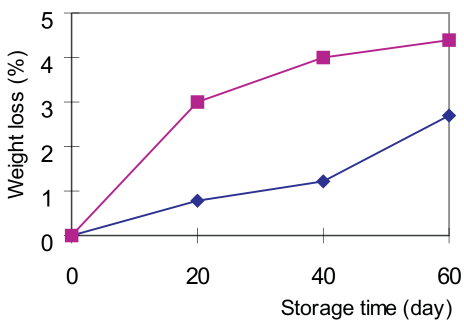

Fig. 5. The weight loss rate during storage. Legend as in Fig. 2.

Texture changes were monitored mainly by the resistance to pressure. Figure 6 shows pressure tolerance, deformation changes and resistance to pressure, respectively.

At the initial stage of preservation, protopectin, the main pectic substance in grapes, is closely associated with the cell wall cellulose. Also, high water content in grapes increases expansion pressure of the cells and rigidity 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 becomes soft. If the transformation goes on to the stage of pectic acid formation, the texture would become softer and the fruit would rot and loose its edible and commercial values (Peng, 1994; Tao, 1999).

The losses of water during storage contribute to the decrease of cell expansion pressure which would also affect, gradually, resistance to pressure. From the results of this study, it can be seen that Teng Ren shows a little decrease in the resistance to pressure. The initial and final values were 1.79 and 0.94 N mm^{-1}, respectively. After 60 days of storage, there is no distinct difference in flavour and taste compared to fresh grapes. But, there is a significant increase of the rotting-rate in the European No. 5, the texture is soften, resistance to press decreases from 1.93 to 0.32 N mm^{-1}. Preservation is not effective with the European No. 5.

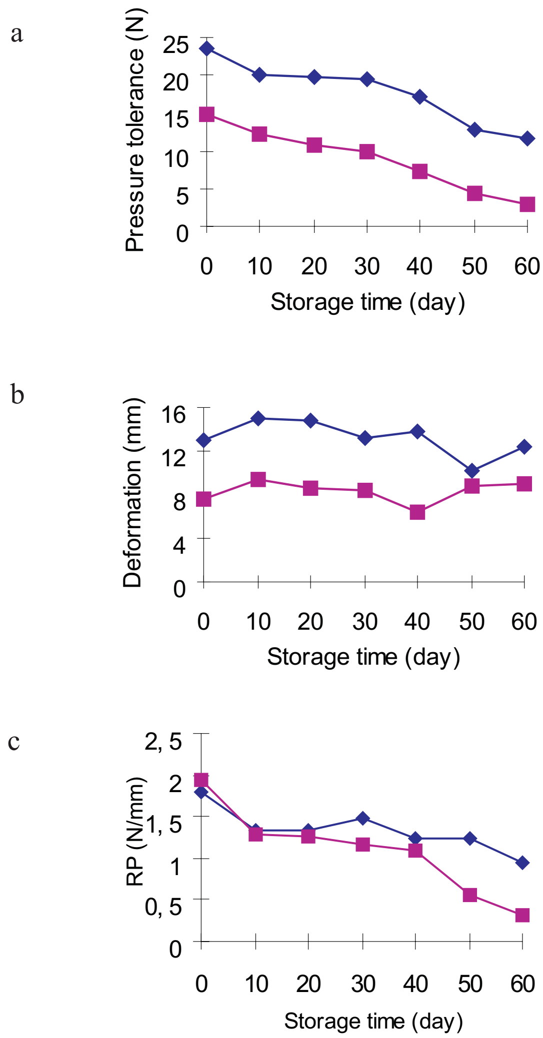

Fig. 6. Changes of pressure tolerance (a), deformation after texture breaking (b), and resistance to pressure RP (c). Legend as in Fig. 2.

CONCLUSION

Preservation of the two types of grapes under the ITHH conditions shows that there is a small change in texture, chemical composition, RI, weight and rot-rate of the Tengren which shows a good storage behaviour. Though the rot-rate in the ITHH preservation seems to be higher for the European No. 5, it is still very low, compared to the normal cold storage. It overcomes a short shelf-life and avoids high rot-rate and weight losses as observed for the normal cold preservation. It also allowed to avoid deterioration of texture as seen in the frozen storage. The ITHH technique is really a useful method for fresh preservation. We believe that, through further investigations, the ITHH preservation would become a prospective method for fresh preservation of other fruit and vegetables.

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