Effect of 1-MCP treatment on preservation and quality of ‘Jinyan’ kiwifruit

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Abstract. The experiment is carried out with the ‘Jinyan’ kiwifruit planted in Pujiang City, in the Sichuan Province as a test material. Under the sealed condition of PE fresh-keeping bag, the effect of different concentrations of 1-MCP on the storage and preservation of ‘Jinyan’ kiwifruit is studied. The result shows that under the normal temperature storage condition, the suitable concentration of 1-MCP can slow down the fruit hardness of ‘Jinyan’ kiwifruit during storage, reduce the rot rate and water loss rate, and make ‘Jinyan’ kiwifruit in storage process maintain high soluble solid content, inhibit the decrease of titratable acid content and VC content, prolong the storage time of ‘Jinyan’ kiwifruit, and effectively maintain the physiological quality of ‘Jinyan’ kiwifruit. Among them, 1-MCP perform best in the storage and preservation of ‘Jinyan’ kiwifruit at a concentration of 375 mgꞏL⁻¹.

1. Introduction

Actinidia chinensis Planch., a genus of vine, has soft fruit texture, with sweet and sour taste, rich nutrition, unique flavour, rich in VC, high nutritional value and broad development prospect[1]. The fruit of kiwifruit is a thin and juicy berry. It is a typical climacteric fruit, the fruit is extremely sensitive to ethylene after harvest, which is easy to cause aging and deterioration[2-5], which affect its appearance quality and intrinsic quality. The annual loss rate of kiwifruit due to improper storage is more than 25% [6]. Therefore, it is very important to explore how to store kiwifruit efficiently.

1-Methylcyclopropene (1-MCP) is a competitive inhibitor of ethylene action that further regulates the ethylene response of plant tissues through binding to ethylene receptor proteins[7]. Wang et al.[8] shows that 1-MCP treatment can significantly prolong the storage and shelf life of kiwifruit, maintain the appearance quality and nutritional value of the fruit, and have no adverse effects on the quality of the post-ripening[9]. At present, the method of preserving the fruit by 1-MCP is not standardized, especially in some new varieties and the fruit by treated often suffer from reducing post-ripening quality or accelerated decay. ‘Jinyan’ kiwifruit is a new variety of kiwi with great market potential, this experiment will focus on how to extend its storage period and clarify the effect of 1-MCP microcapsules on fruit preservation and quality, determine the optimal dose, to provide a scientific basis for the promotion and application of 1-MCP products and the preservation of ‘Jinyan’ kiwifruit.
2. Materials and Methods

2.1 Test materials
The test material ‘Jinyan’ kiwifruit is picked from Pujiang City, Sichuan Province, on the morning of October 12, 2017. The fruit is fresh and basically same, no disease and mechanical damage, and the ‘Jinyan’ kiwifruit with the same maturity.

2.2 Test design
The experiment mainly uses closed fumigation treatment[10]. On October 12, 2017, ‘Jinyan’ kiwifruit is picked and applied within 24 hours after harvesting. Five concentrations of 1-MCP microcapsules (A1) 125 mg·L⁻¹, (A2) 250 mg·L⁻¹, (A3) 375 mg·L⁻¹ and (A4) 500 mg·L⁻¹ are selected (including control CK) to treat ‘Jinyan’ kiwifruit. Each treatment is repeated 4 times, and 10 fruits are randomly taken before the analysis to measure the physiological index values of the fruits (Fruit weight, fruit firmness, soluble solid content, VC content, titratable acid content, reducing sugar content, invert sugar content, total sugar content). Then, put the kiwifruit into the PE plastic storage bag and put it into a 40 L fruit carton. Then put the 1-MCP drug pack into the fruit carton, seal the fresh-keeping bag, and seal the box mouth to store under normal temperature conditions, on the 10th, 20th, and 30th after treatment, the measurements are performed separately and calculate the content of each treatment. Finally, statistical analysis of the differences between the physiological indicators of fruits in different time periods, select the optimal treatment concentration of 1-MCP.

3. Results

3.1 Effect of 1-MCP Microcapsules on the Hardness of Kiwifruit Fruit at Normal Temperature
It can be seen from Table 1 that, under normal temperature conditions, after treatment with kiwifruit by 1-MCP microcapsules, the hardness of each treatment gradually decreases with time. After 10 days of treatment, the hardness of A1-A3 is significantly higher than that of the control compared with the control; after 20 days of treatment, the A3 treatment is significantly different from other treatments, and the hardness is higher than other treatments; after 30 days of treatment, the hardness of each treatment is significantly higher than the control. It can be seen that the treatment of 1-MCP microcapsules can delay the decrease of fruit firmness and maintain the effect. In the four treatments, 375 mg·L⁻¹ of 1-MCP treat kiwifruit has better preservation effect.

| 1-MCP Concentration | Treatment 0 d | Treatment 10 d | Treatment 20 d | Treatment 30 d |
|---------------------|--------------|----------------|----------------|----------------|
| 0                   | 6.18±0.10c   | 4.93±0.13c     | 3.63±0.22c     |                |
| 125                 | 6.40±0.18ab  | 5.05±0.21c     | 4.18±0.010b    |                |
| 250                 | 6.45±0.06ab  | 5.28±0.10ab    | 4.28±0.126ab   |                |
| 375                 | 6.58±0.10a   | 5.45±0.13a     | 4.53±0.17a     |                |
| 500                 | 6.33±0.13bc  | 5.03±0.17bc    | 4.30±0.25ab    |                |

Note: Different lowercase letters in the same column data indicate significant difference, and the same lowercase letters indicate that the difference is not significant (P<0.05). The table below is the same.

3.2 Effect of 1-MCP Microcapsules on the Weight Loss Rate of Kiwifruit fruit at Normal Temperature
It can be seen from Table 2 that the weight loss rate of kiwifruit after treatment with 1-MCP microcapsules under normal temperature conditions is: CK>A1>A2>A4>A3. Therefore, after treatment with 1-MCP microcapsules, ‘Jinyan’ kiwifruit can effectively maintain the loss of fruit
moisture and delay fruit senescence. Among the four treatments, the treatment with a concentration of 375 mg·L⁻¹ is the best.

Table 2. Effect of 1-MCP microcapsules on the weight loss rate of kiwifruit fruit at normal temperature (%)

| 1-MCP Concentration | Treatment 0 d | Treatment 10 d | Treatment 20 d | Treatment 30 d |
|----------------------|---------------|---------------|---------------|---------------|
| 0                    | 2.35±0.21a    | 3.55±0.13a    | 6.750±0.056a  |
| 125                  | 2.08±0.17b    | 2.63±0.10b    | 5.63±0.17b    |
| 250                  | 2.05±0.10b    | 2.65±0.19b    | 5.10±0.09c    |
| 375                  | 1.90±0.14b    | 2.30±0.16c    | 4.33±0.21e    |
| 500                  | 1.98±0.10b    | 2.33±0.17c    | 4.75±0.21d    |

3.3 Effect of 1-MCP Microcapsules on Fruit Rotten Fruit Rate at Normal Temperature

It can be seen from Table 3 that the rot rate of kiwifruit is significantly reduced after treatment with 1-MCP microcapsules under normal temperature conditions. In particular, A3 has a better treatment effect, which can effectively prolong the shelf life of kiwifruit and increase the economic value of the commodity.

Table 3. Effect of 1-MCP microcapsules on the rate of rotten fruit of Kiwifruit fruit at normal temperature (%)

| 1-MCP Concentration | Treatment 0 d | Treatment 10 d | Treatment 20 d | Treatment 30 d |
|----------------------|---------------|---------------|---------------|---------------|
| 0                    | 1.15±0.13a    | 9.65±0.24a    | 33.18±0.86a   |
| 125                  | 0b            | 7.40±0.16b    | 23.88±2.44b   |
| 250                  | 0b            | 6.45±0.21c    | 23.13±2.11bc  |
| 375                  | 0b            | 3.35±0.13e    | 13.33±1.35d   |
| 500                  | 0b            | 5.90±0.47d    | 19.65±1.29c   |

3.4 Effects of 1-MCP Microcapsules on the Content of Soluble Solids in Kiwifruit Fruit at normal Temperature

As can be seen from Table 4, after application of 1-MCP microcapsules under normal temperature conditions, the soluble solid content of kiwifruit increase after 20 days of treatment, and decrease after the 30th day, this may be due to the post-ripening effect of kiwifruit. Relatively speaking, A3 treatment is better.

Table 4. Effect of 1-MCP microcapsules on the content of soluble solids in Kiwifruit fruit at normal temperature (%)

| 1-MCP Concentration | Treatment 0 d | Treatment 10 d | Treatment 20 d | Treatment 30 d |
|----------------------|---------------|---------------|---------------|---------------|
| 0                    | 8.43±0.36a    | 11.05±0.24a   | 7.66±0.30c    |
| 125                  | 7.40±0.22b    | 10.55±0.25b   | 8.43±0.24b    |
| 250                  | 7.20±0.29b    | 10.60±0.26b   | 8.43±0.17b    |
| 375                  | 7.18±0.10b    | 10.58±0.17b   | 9.30±0.18a    |
3.5 Effect of 1-MCP Microcapsules on the titratable acid Content of Kiwifruit Fruit at Normal Temperature
As can be seen from Table 5, after treatment with 1-MCP microcapsules, over time, the titratable acid content of the fruit shows a downward trend. Among them, A3 works best, it can inhibit the decline of titratable acid content of kiwifruit to the greatest extent, effectively prolong the shelf life of kiwifruit, increase the value of commodities, and achieve the effect of storage and preservation.

Table 5. Effect of 1-MCP microcapsules on the titratable acid content of kiwifruit fruit at normal temperature [g (100 mL)⁻¹]

| 1-MCP Concentration | Treatment 0 d | Treatment 10 d  | Treatment 20 d  | Treatment 30 d  |
|----------------------|---------------|-----------------|-----------------|-----------------|
| 0                    | 1.23          | 1.16±0.03bc     | 0.90±0.01b      |
| 125                  | 1.40±0.40a    | 1.18±0.01ab     | 0.94±0.02b      |
| 250                  | 1.24±0.02b    | 1.16±0.02bc     | 0.97±0.01ab     |
| 375                  | 1.28±0.01b    | 1.19±0.10a      | 1.03±0.12a      |
| 500                  | 1.20±0.01c    | 1.15±0.10c      | 0.94±0.02b      |

3.6 Effect of 1-MCP Microcapsules on VC Content in Kiwifruit fruit at normal Temperature
The results in Table 6 indicate that after treatment with 1-MCP microcapsules at normal temperature, the VC content of kiwifruit fruit decrease with the delay of storage time. However, A3 processing has the smallest reduction, it indicated that A3 treatment can better inhibit the decrease of VC content in kiwifruit.

Table 6. Effect of 1-MCP microcapsules on VC content in kiwifruit fruit at normal temperature [mg (100 mL)⁻¹]

| 1-MCP Concentration | Treatment 0 d | Treatment 10 d | Treatment 20 d | Treatment 30 d |
|----------------------|---------------|----------------|----------------|----------------|
| 0                    | 110.24±1.01d  | 62.05±0.98c    | 41.32±0.98d    |
| 125                  | 114.92±0.49c  | 78.69±0.44b    | 67.55±2.12c    |
| 250                  | 118.06±0.89b  | 79.80±0.46b    | 72.11±1.32b    |
| 375                  | 120.38±0.81a  | 83.82±1.24a    | 79.95±1.49a    |
| 500                  | 117.10±1.82b  | 79.95±0.60b    | 72.76±2.11b    |

3.7 Effects of 1-MCP microcapsules on reducing sugar, invert sugar and total sugar content of kiwifruit at normal temperature
Fruit reduce sugar, invert sugar and total sugar content are important indicators of fruit maturity, which can reflect fruit development stage and fruit picking period. It can be seen from Table 7, Table 8, and Table 9, after 1-MCP treatment, the content of reducing sugar, invert sugar and total sugar in most treat fruits show a trend of increase first and then decrease in 10-30 d, the A3 shows a steady growth trend. It can be seen that in 10-30 d, A3 has been in a stage of gradual maturation. On the contrary, on the 20th day, the fruits of the other treatment groups and the control group reach physiological maturity, and the reduce sugar, invert sugar and total sugar content of the fruit peak and then decrease. It is indicated that A3 is most beneficial to control the content of reducing sugar, invert
sugar and total sugar, and can effectively control the ripening of kiwifruit, thereby improve the storability of kiwifruit.

| 1-MCP Concentration | Treatment 0 d | Treatment 10 d | Treatment 20 d | Treatment 30 d |
|----------------------|---------------|----------------|----------------|---------------|
| 0                    | 6.54±0.16a    | 7.77±0.17a     | 4.15±0.08c     |
| 125                  | 6.09±0.06ab   | 7.79±0.60b     | 6.24±0.08b     |
| 250                  | 5.16±0.15c    | 7.49±0.03b     | 6.71±0.18a     |
| 375                  | 5.41±0.11b    | 6.61±0.60d     | 6.79±0.04a     |
| 500                  | 5.53±0.22b    | 7.26±0.12c     | 6.79±0.10a     |

Table 8. Effect of 1-MCP microcapsules on inverted sugar content of Kiwifruit fruit at normal temperature [mg·(100 mL)⁻¹]

| 1-MCP Concentration | Treatment 0 d | Treatment 10 d | Treatment 20 d | Treatment 30 d |
|----------------------|---------------|----------------|----------------|---------------|
| 0                    | 7.63±0.10a    | 10.31±0.18a    | 6.54±0.08e     |
| 125                  | 7.33±0.10b    | 9.91±0.06b     | 7.21±0.16d     |
| 250                  | 6.78±0.16c    | 9.23±0.10e     | 8.10±0.11b     |
| 375                  | 6.23±0.06d    | 8.70±0.15d     | 9.23±0.10a     |
| 500                  | 6.65±0.10c    | 9.57±0.10c     | 7.73±0.12c     |

Table 9. Effect of 1-MCP microcapsules on total sugar content of kiwifruit fruit at normal temperature [mg·(100 mL)⁻¹]

| 1-MCP Concentration | Treatment 0 d | Treatment 10 d | Treatment 20 d | Treatment 30 d |
|----------------------|---------------|----------------|----------------|---------------|
| 0                    | 7.58±0.13a    | 10.19±0.16a    | 6.43±0.07e     |
| 125                  | 7.27±0.10b    | 9.79±0.06b     | 7.16±0.15d     |
| 250                  | 6.70±0.15c    | 9.15±0.10d     | 8.03±0.10b     |
| 375                  | 6.19±0.06d    | 8.60±0.13c     | 9.11±0.10a     |
| 500                  | 6.59±0.10c    | 9.45±0.10c     | 7.68±0.11c     |

4. Discussion and Conclusion
In this experiment, the following conclusions are drawn from the study on the physiological and biochemical characteristics of ‘Jinyan’ kiwifruit: Treating ‘Jinyan’ kiwifruit with four different concentrations of 1-MCP, it can extend the shelf life of kiwifruit to a certain extent, slow down the decline in the hardness of ‘Jinyan’ kiwifruit, maintain a high soluble solid content for a certain period of time. It also can inhibit the decrease of titratable acid content and VC content and control sugar content, reduce the rate of rotten fruit, water loss rate, slow down fruit senescence, and improve the
quality of kiwifruit to achieve the purpose of storage and preservation. According to the analysis, when the concentration of 1-MCP is 375 mg·L⁻¹, the performance is the best.

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