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Effects of High / Low Oxygen Combined With 1-MCP on The Quality and Volatile Components of Mints During Storage

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Abstract. To investigate the effect of high / low oxygen combined with 1-methylcyclopropene (1-MCP) on the quality and volatile components of mints during storage, and to analyze the intrinsic relationship between volatile components and peppermint quality. Using high-quality mints as the test materials, 1-MCP with concentrations of 0.5 μ L/L and 1.0 μ L/L were combined with low oxygen (6% O_2:9% CO_2: 85% N_2) and high oxygen (80% O_2: 20% CO_2) to treat mints, stored at 4℃ for 12 days, and the physiological and biochemical changes of mints during storage were analyzed. The volatile components in peppermint were also measured. The results showed that: under the condition of 4℃, the combination of 0.5 μ L/L 1-MCP and low oxygen (6% O_2:9% CO_2: 85% N_2) treatment could reduce the loss of volatile components , inhibit the degradation of chlorophyll and the generation of ethylene, reduce the activity of peroxidase (POD) enzyme, and achieve good preservation effect in mints. The better the quality of mint, the more terpenes in mint volatile, the less alcohols.

1 Introduction

Mint, also known as orchid fragrance, is one of the medicinal and edible materials with rich chemical components. It is commonly used to treat external infections such as wind and heat, headache, throat obstruction, mouth sores, measles, and qi stagnation and other diseases [1].

1-Methylcyclopropene (1-MCP) is a novel ethylene receptor inhibitor that can specifically bind to ethylene receptors, preventing the induction of exogenous ethylene and the synthesis of endogenous ethylene, thereby reducing the respiratory intensity of fruits and vegetables during storage, prolonging their storage period. Therefore, 1-MCP has broad application prospects in fruit and vegetable storage and preservation [2]. At present, research on peppermint both domestically and internationally was mainly focused on its medicinal value and the volatile oil of mints, for the preservation of mint research only low temperature, different packaging material and low oxygen packaging way [3-4], There were few reports on the use of different gas ratios combined with preservatives to preserve mint, and the evaluation of mint quality based on indicators such as volatile components.

The main purpose of this research was to explore the beneficial conditions for mint preservation and the intrinsic relationship between volatile substances and mint quality during storage by adjusting different gas ratios combined with 1-MCP treatment to determine physiological and biochemical indicators and volatile components of mint. The aim was to identify indicators of volatile substances that could reflect mint quality and provide a scientific basis for improving mint preservation by controlling the composition of volatile substances in the future.

2 Materials and Methods

2.1 Materials

Mint, purchased from the market.

2.2 Experimental methods

2.2.1 Mint pretreatment

Take fresh mint with intact individuals, no leaf defects or rotting leaves. Divide the 1-MCP solution with concentrations of 0.5μL/L and 1.0μL/L into two beakers, take a blank control (CK), and place 1kg of fresh mint in each of the three sealed boxes, sealed. Store at 4 ℃ for 12 hours, then packed the processed mint into packaging bags and filled them with the corresponding gas ratios, as shown in Table 1.

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Table 1. Effects of different treatment methods on the preservation effect of mint.

Number	Gas ratio (O_2: CO_2: N_2)	1-MCP concentration
A	6:9:85	0.5μL/L
B	6:9:85	1.0μL/L
C	80:20:0	0.5μL/L
D	80:20:0	1.0μL/L
CK	-	-

2.2.2 Determination of weight loss rate

Reference method[5] adopted weighing method.

2.2.3 Determination of respiration intensity

Using a fruit and vegetable respiration meter, measure the concentration of carbon dioxide to calculate the respiration rate of peppermint.

Calculate according to the following formula:

Respiratory intensity Q (mgCO2/kg·h)

$$= \frac{F \times 60 \times C}{22.4} \times \frac{44}{W} \times 10^{-6} \times \frac{273}{273+T}$$

2.2.4 Determination of POD enzyme activity

Refer to the method[5] for determination.

2.2.5 Determination of ethylene content

Refer to the method[6] for determination.

2.2.6 Determination of aroma components

Refer to the method[7] for determination.

2.3 Data processing

The obtained data were statistically analyzed and processed with standard deviation by Excel software, and the results were expressed as the mean values of the three parallel results.

3 Results and analysis

3.1 The weight loss rate

As shown in Fig 1, the weight loss rate of each treatment group during the storage period showed an upward trend with the increase of storage time. The weight loss rate of group D increased rapidly, significantly higher than other treatment groups; The weight loss rate of group A remained relatively low and increased slowly, with a weight loss rate of only 5.67% on the 12th day. This indicated that low oxygen regulation combined with 0.5μL/L 1-MCP treatment could effectively alleviate the dehydration and wilting of peppermint caused by vigorous respiration and transpiration, reduce the weight loss rate of peppermint, and achieve the effect of extending shelf life.

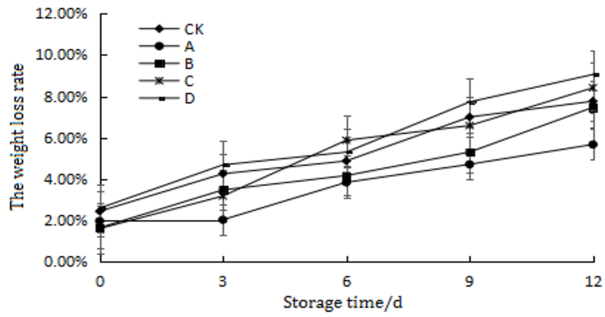

Fig. 1. Effect of different treatment groups on the weight loss rate of mints.

3.2 The respiratory intensity

As shown in Fig. 2, the respiratory intensity changes of different treatment groups of peppermint were observed. The CK group showed a respiratory peak on the 3rd day, while the other four treated groups all reached their respiratory peak on the 6th day. Among them, the peak respiratory intensity of A was 609.28 mgCO_2/(kg·h), which was significantly lower than that of the group B, C, and D. During the 6th to 9th day of storage, the respiratory intensity of group B rapidly decreased. By the 12th day, the respiratory intensity was only higher than that of group A, indicating that low oxygen regulation could effectively reduce the respiratory intensity of mints. The results showed that the combination of MCP and controlled atmosphere could delay the occurrence of respiratory peak, and the preservation effect of 0.5μL/L 1-MCP combined with low oxygen content on peppermint was better than other groups, which could better control respiratory metabolism to a lower level.

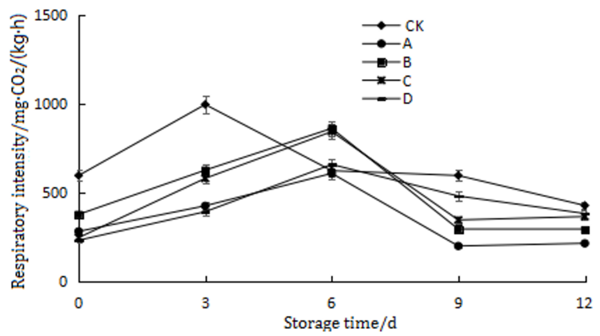

Fig. 2. Effect of different treatment groups on the respiratory intensity of mints.

3.3 The POD enzymatic activity

As shown in Fig. 3, during the storage period, the POD enzyme activity of the group C reached its highest value at 149.2 $U \cdot g^{-1} \cdot min^{-1}$ until the 6th day of storage, and its enzymatic activity was significantly higher than that of other groups. However, the POD enzyme activity of group A remained relatively low during storage, indicating that treatment with group A (0.5μL/L 1-MCP combined with low oxygen content) could better inhibit POD enzyme activity, delay tissue aging, and improve the quality of products.

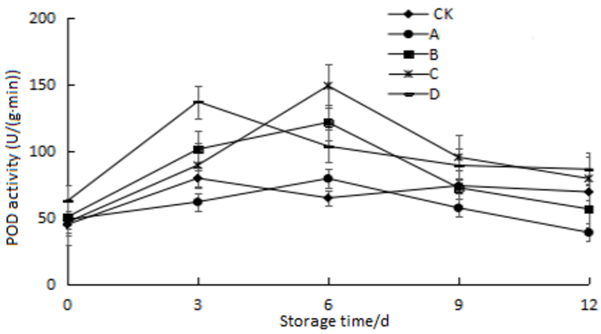

Fig. 3. Effects of different treatment groups on POD enzyme activity in mints.

3.4 The ethylene content

From Fig. 4, it could be seen that the CK group had the highest ethylene content released from peppermint, while the four groups treated with 1-MCP had lower ethylene content released, indicating that 1-MCP treatment could effectively inhibit the generation of ethylene. The ethylene content of mints treated with group C and group D increased rapidly, while the ethylene content of mints treated with group A and group B with low oxygen content increased slowly. Among them, the group A with lower 1-MCP concentration had the lowest ethylene content. When stored for 12 days, the ethylene content was only 0.101μL/kg·h. This might be due to the fact that 1-MCP acts on the surface of fruits and vegetables, reducing the sensitivity of tissues to ethylene, thereby effectively inhibiting the increase in ethylene content. Therefore, a concentration of 0.5μL/L of 1-MCP combined with low oxygen could better inhibit the production of ethylene in peppermint, slow down leaf aging rate, and improve mint storage quality.

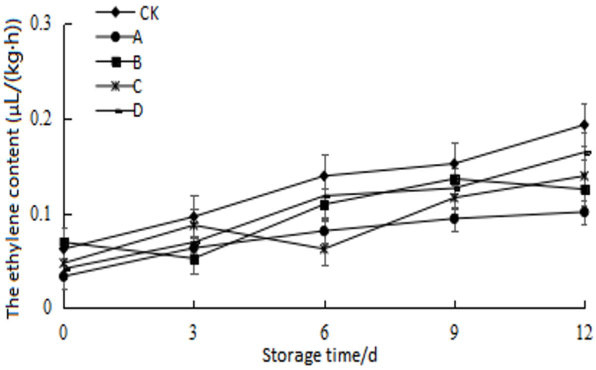

Fig. 4. Effect of different treatment groups on the ethylene content of mints.

3.5 The aroma components

The main components of volatile aroma in peppermint leaves were terpenes, alcohols, ketones, esters, acids, and other compounds. Among them, 15 terpenes (mainly composed of D-limonene, caryophyllene, caryophyllene, camphorene, β- myrcene, etc.) accounted for 32.36% of the total aromatic substances, and 7 alcohols (mainly composed of dihydrocarvacrol, linalool, cis coumarin, α-isodecanol, etc.) accounted for 22.23% of the total aromatic substances. One ketone was D-carvone, which accounted for 30.39% of the measured weight of aromatic substances. In addition, there were two types of esters and two types of acids, but they accounted for a relatively small proportion of the total volatile substances.

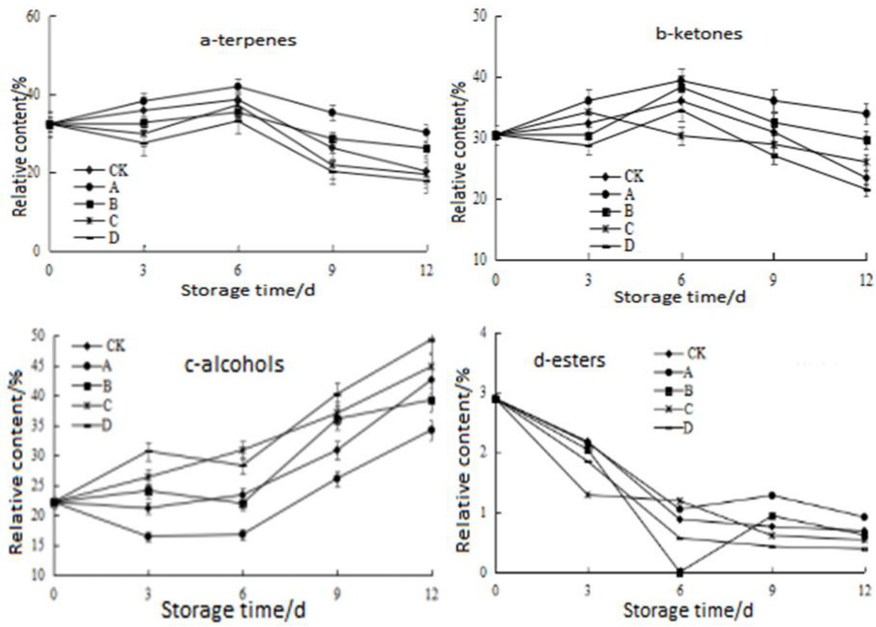

Fig. 5. Changes in the content of various substances in peppermint during storage.

From Fig. 5-a, it could be seen that during the entire storage period, the relative content of terpenes in mints showed a trend of first increasing and then decreasing. The main reason might be that as the mint leaves matured, terpenes gradually increased, but as the storage time prolonged, the quality of peppermint began to decline, and thus the volatile terpenes began to decrease. Overall, the loss of terpenes was as follows: CK>D>C>B>A. Therefore, low oxygen conditions could change the gas composition inside the packaging bag, inhibit its respiration, and thus reduce the decomposition rate of terpenes, slowing down the loss of terpenes in peppermint.When 0.5μL/L of 1-MCP+low oxygen was combined to treat peppermint, the loss rate was the slowest and the effect was better.

It showed in Fig. 5-b that the relative content of ketone compounds in peppermint treated with 1-MCP +low oxygen modulation was consistently higher than that under other treatment conditions. The combination of 1-MCP and low oxygen conditioning treatment could effectively maintain the content of ketones in mints, whichwas consistent with Jia Ying's research [8].

From Fig. 5-c, it could be seen that during the entire storage process, the growth of alcohol substances was relatively slow in the early stage of storage, but rapidly increased in the later stage. This might be due to the fact that some lipids in peppermint generate hydrogen peroxide under the action of oxidase, which then decomposes into aldehydes under the action of peroxidase, further oxidizing into alcohol substances, resulting in an increase in alcohol substances. When stored for 12 days, the relative content of group A was significantly ($P<0.05$) lower than the other four groups, indicating that the 0.5μL/L 1-MCP+low oxygen treatment had a better inhibitory effect on alcohol substances.

According to Fig. 5-d, ester substances showed a trend of first increasing and then decreasing. After storage until the 6th day, the ester content in groups A, B, C, and D was significantly ($p<0.05$) lower than that in the CK group. The results showed that each treatment condition could slow down the generation of ester substances, it might be that 1-MCP could bind to ethylene receptors, it exerted an inhibitory effect on ethylene. In the later stage of storage, the content of esters in group A was higher than that in other groups, indicating that 0.5μL/L of 1-MCP+low oxygen treatment could delay the loss of esters in mints.

Thus, it could be seen that the combination of 0.5 μL/L 1-MCP and low oxygen conditioning treatment could help slow down the reduction of terpene compounds in peppermint leaves and maintain the aroma components of peppermint. Mints produced an aromatic odor as its leaves mature, and aldehydes caould catalyze the formation of corresponding alcohols, leading to an increase in alcohol content and the production of unpleasant odors that affect the value of peppermint.

4 Conclusion

This experiment investigated the effects of high/low oxygen combined with different concentrations of 1-MCP treatment on volatile compounds and quality of peppermint during storage at 4℃. A: Low oxygen (6% O_2: 9% CO_2: 85% N_2)+0.5μL/L 1-MCP; B: Low oxygen (6% O_2: 9% CO_2: 85% N_2)+1.0μL/L 1-MCP; C: High oxygen(80% O_2: 20% CO_2)+0.5μL/L 1-MCP; D: High oxygen (80% O_2: 20% CO_2)+1.0μL/L 1-MCP. It was found that the combination of 0.5μL/L 1-MCP and low oxygen (6% O_2: 9% CO_2: 85% N_2) treatment could reduce the loss of volatile components in peppermint, inhibit the degradation of chlorophyll and the generation of ethylene, reduce the activity of POD enzyme, achieve better preservation effect, and improve the quality of peppermint. In addition, a total of 29 aroma components were detected in peppermint, mainly ketones and alcohols. Under four treatment conditions, the low oxygen modulation combined with 0.5μL/L 1-MCP treatment resulted in the lowest rate of loss of peppermint aroma components and inhibited the increase of alcohol compounds, helping to maintain the aroma of peppermint leaves. The results showed that the more terpenes and fewer alcohols in the volatile substances of peppermint, the better the preservation effect of peppermint. This lays a theoretical foundation for improving the preservation effect of peppermint by controlling the composition of volatile substances in the future.

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