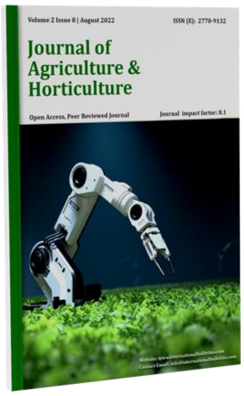

THE INFLUENCE OF VARIOUS TREATMENTS ON THE PHYSICOCHEMICAL TRAITS OF 'TOYFI PINK' GRAPES DURING COLD STORAGE.

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Abstract: Low temperature storage is commonly employed to preserve the postharvest quality of table grapes. However, grape clusters are prone to deterioration if left untreated during storage. This study aimed to assess the impact of postharvest treatments with 1-methylcyclopropene (1-MCP), calcium chloride (1%), ethanol (16%), and a combination of 1-MCP with calcium chloride and ethanol on the preservation of the quality of "Toyfi Pink" table grapes stored at 5°C and 0°C. The research focused on changes in decay incidence, weight loss, rachis browning, and overall quality indicators of the grape clusters. The results indicated that all treatments significantly reduced decay, weight loss, and rachis browning at both storage temperatures. 1-MCP was particularly effective in reducing decay during the early storage period but had no significant impact in the later stages. There were no significant differences in taste or color quality indicators across both temperatures, regardless of the treatments. The overall findings suggest that the combination of 1-MCP with calcium chloride and ethanol is optimal for short-term storage at 0°C, while calcium chloride (1%) and ethanol (16%) alone are recommended for long-term storage at this temperature.

Keywords: *Shelf-life, rachis browning, fruit quality, physicochemical changes, mechanisms, soluble solid content*

1. Introduction

The grapevine (Vitis vinifera L.) is a key fruit crop with significant economic value globally, with approximately 90% of its production in China used for fresh fruit consumption. Traditionally, table grapes have been considered highly perishable, non-climacteric fruits with minimal physiological activity. However, they are prone to postharvest losses, such as decay, water loss, and rachis browning, which occur after harvest and during extended storage [1]. As the fruit market becomes increasingly competitive, there is a growing demand for high-quality grapes. Due to the influence of consumer preferences and market pricing, the quality of table grapes has gained greater attention from producers and exporters. Consequently, grape producers are continually seeking new technologies to preserve the fresh appearance of grape clusters post-harvest. In some instances, vineyards are located far from the market, requiring the development of innovative technologies to slow or inhibit the physicochemical changes that occur during long-term storage of grapes harvested at their peak quality [2].

Currently, low-temperature storage is the most widely used postharvest method to preserve fruit quality and extend shelf life. However, the storage duration of table grapes is limited at low temperatures, and without proper treatment, their commercial value diminishes over time. As a result, various postharvest treatments combined with low-temperature storage have been explored to maintain grape quality. The use of sulfur dioxide (SO_2) is the most common commercial method for extending the postharvest life and maintaining the quality of grape clusters. Additionally, controlled atmospheres with high CO_2 levels under continuous flow have proven effective in controlling postharvest diseases and prolonging short-term storage of table grapes [3]. However, controlling these atmospheres can be challenging, and SO_2 use is heavily restricted in many countries due to its harmful residues, which pose health risks and may cause phytotoxicity in fruit. Growing awareness among producers and consumers about the potential hazards of chemical treatments during postharvest storage has driven the development of safer alternatives. As a result, there is a push for more environmentally friendly and non-toxic treatments for the storage of table grapes.

As an alternative technology, 1-MCP is being explored as an ethylene inhibitor. It works by blocking ethylene from binding to its receptor, which prevents downstream signal transduction at very low concentrations, thereby delaying fruit ripening and enhancing the storage quality of various horticultural products. Studies have shown that 1-MCP, either alone or in combination with other preservation methods, can extend the storage life of fruits such as grapes, bananas, blueberries, figs, apples, and persimmons. Ethanol, a widely used and inexpensive food additive with antimicrobial properties, has proven effective in preventing postharvest fungal infections in many fruits when applied as vapor or through dipping. However, maintaining the right concentration of ethanol vapor in work environments can be challenging, reducing its practicality. Additionally, high concentrations of ethanol can increase treatment costs and pose environmental, safety, and osmotic damage risks to fruit tissue. Dipping in ethanol, however, is a cost-effective and safe postharvest treatment that has been shown to improve the storage life of table grapes by limiting postharvest rot development. Calcium, as a secondary messenger, plays a vital role in regulating physiological processes and preserving fruit storage quality. Previous studies have indicated that calcium spraying can enhance grape berries' resistance to both abiotic and biotic stresses, extending their shelf life.

Research by Nigro et al. found that treating grapes with a 16% ethanol solution combined with 1% calcium chloride significantly reduced the incidence of rotten clusters. Moreover, postharvest treatments with calcium chloride have been shown to delay softening in apples and reduce the occurrence of physiological disorders. “Toyfi Pink” grapes, a popular variety known for their crisp texture, large berries, and favorable sugar-acid ratio, are one of the most commercially important grape varieties in Uzbekistan. However, these grape clusters are prone to rapid deterioration if not properly treated after harvest. Thus, the objective of our study was to assess the effects of 1-MCP, calcium chloride, ethanol, and their combination on maintaining the postharvest quality and extending the storage time of grape berries. Our aim was to develop an economic and safe postharvest technology for preserving the quality of table grapes [4].

2. Materials and Methods

2.1. Materials and Treatments

The table grapes “Toyfi Pink” were harvested on September 14, 2020, from a vineyard in Parkent, Tashkent region, Uzbekistan. Grapes were manually harvested at commercial maturity and transported immediately to the laboratory. The grape clusters were selected for uniform size, color, and firmness, with no signs of damage or mold, and were randomly divided into batches for the postharvest experiment. Approximately 5 kg of grapes were selected as the initial sample for storage, while the remaining berries were pre-cooled at 5°C for 12 hours.

Figure 1. Harvested "Toyfi Pink" table grapes

On the following day, the pre-cooled grapes were randomly assigned to four experimental treatment groups (each repeated three times), as follows: (1) 1-MCP: Grapes were fully immersed in a 1 µg/kg aqueous 1-MCP solution for 5 minutes, then air-dried; (2) Calcium chloride and ethanol: Grapes were sprayed with a 16% aqueous ethanol solution containing 1% calcium chloride; (3) Combined 1-MCP with calcium chloride and ethanol: Grapes were immersed in 1 µg/kg aqueous 1-MCP for 5 minutes, air-dried, and then sprayed with the ethanol-calcium chloride solution; (4) Control: Grapes received no treatment. For each treatment, about 3 kg of grapes were weighed and neatly arranged in a single layer inside open packing boxes. The grapes in each treatment were then divided into two groups, stored at 0°C and 5°C with humidity maintained between 85–95%.

2.2 Measurement of Decay Incidence, Weight Loss, Rachis Browning, and Firmness

Grapes were randomly sampled at 15, 30, 45, 60, and 75 days of storage to assess biochemical changes. Five grape clusters from each group were used to measure decay incidence, weight loss, and rachis browning. Decay incidence was determined by calculating the percentage of rotten grapes at each sampling point for each treatment. Weight loss was measured by weighing the grapes at the start of the experiment and every two weeks thereafter. Weight loss was expressed as the percentage of weight lost relative to the initial weight. Rachis browning was assessed on a subjective scale based on previous studies: (0) no browning; (1) slight browning (less than a quarter of the rachis and cap stems); (2) moderate browning (browning in up to half of the rachis and cap stems); (3) severe browning (browning in more than half but less than three-quarters); (4) extreme browning (browning in more than three-quarters of the rachis and cap stems). Rachis browning was expressed as the percentage of the rachis area affected. Firmness was measured using a Ta-XT2i Plus texture analyzer (Stable Micro Systems, UK) with a 2 mm flat probe. A total of 30 berries from each treatment were selected at each sampling point [5].

3. Results

Decay is one of the primary causes of postharvest loss in grape berries. In this study, decay incidence was monitored throughout the storage period until it exceeded 50%. The decay incidence increased with the extension of the storage time. It is evident that the decay incidence of grape berries stored at 0°C was significantly lower than at 5°C across the entire storage period, suggesting that low temperature is effective in reducing decay. During the first month of storage, decay incidence remained relatively low, and all treatments had a significantly lower decay incidence compared to the control group at both storage temperatures. However, after a month, the decay incidence increased significantly, particularly for the 1-MCP-treated grapes. Within two months, the decay incidence at 5°C exceeded 50% for all treatments, marking the end of the experiment at this temperature. At the conclusion of the 5°C storage, significant differences were observed among treatments, with the lowest decay incidence (10.95%) recorded in the combined 1-MCP with calcium chloride and ethanol treatment, and the highest (25.32%) in the control treatment. At 0°C, the decay incidence increased rapidly in all treatments after two months, with the control group showing the most significant increase. Notably, during the second month of storage, decay incidence varied considerably between treatments, from lowest to highest: calcium chloride and ethanol (12.31%), combined 1-MCP with calcium chloride and ethanol (24.57%), 1-MCP (33.5%), and control (40.01%). On day 75, at the end of the storage period at 0°C, the decay incidence of the calcium chloride and ethanol treatment (17.36%) was significantly lower than that of the 1-MCP (50.76%) and control (51.72%) treatments. This result indicates that 1-MCP had a positive effect during the early stages of storage but was less effective in the later stages for maintaining the quality of postharvest grape berries.

4. Discussion

Postharvest table grape berries undergo a process of quality deterioration, including decay, weight loss, and rachis browning, which worsen as storage time increases. Inappropriate postharvest treatments can accelerate this quality deterioration process. To evaluate the effectiveness of various harmless treatments on table grape storage, we conducted decay and fruit quality assays on grapes under different treatments at both low temperatures. Gray mold infection (*Botrytis cinerea*), which causes berry decay, is a critical issue for postharvest loss in grapes [6]. 1-MCP has been proven effective in various climacteric and non-climacteric fruits for extending storage time and maintaining product quality. Weight loss is an important and objective measure for evaluating the response of horticultural products to postharvest treatments.

This weight loss primarily results from water evaporation due to transpiration and respiration processes during storage. 1-MCP has been shown to significantly reduce respiration, thus minimizing water loss. Research indicates that postharvest calcium treatment alters gas diffusion rates, leading to the inhibition of respiratory metabolism. Furthermore, calcium, a key component of the cell wall, helps strengthen the cell wall, which in turn retards weight loss in grapes. In the present study, treatments with 1-MCP, calcium chloride (1%), ethanol (16%), and the combined treatment of 1-MCP with calcium chloride and ethanol all significantly reduced weight loss in the stored grapes [7].

5. Conclusions

In conclusion, our results provide strong evidence that 1-MCP, calcium chloride, and ethanol, as well as the combination of 1-MCP with calcium chloride and ethanol treatments, can significantly reduce decay incidence, weight loss, and rachis browning, helping to maintain grape quality during low-temperature storage. Generally, low-temperature storage, particularly at 0°C, is the most effective treatment for preserving postharvest grape quality. Based on our findings, the combination of 1-MCP with calcium chloride and ethanol should be preferred for short-term table grape storage at 0°C. However, for long-term storage, calcium chloride and ethanol treatment alone should be used, while still storing the grapes at 0°C for optimal quality preservation.

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