Title: **Integrated preharvest salicylic acid maleic hydrazide and postharvest 1 MCP delay softening and preserve strawberry quality during cold storage**

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Abstract: A two-year investigation (2023–2024) was conducted to evaluate the integrated influence of preharvest salicylic acid (SA) and maleic hydrazide (MH) treatments, alone and in combination, with a postharvest 1-methylcyclopropene (1-MCP) application on the postharvest physiology, biochemical quality and antioxidant defense mechanisms of strawberry (*Fragaria* × *ananassa* Duch.) fruits during cold storage. Results revealed that the combined preharvest application of SA + MH (T_4), further reinforced by postharvest 1-MCP treatment (T_5), markedly enhanced firmness retention, with T_5 fruits exhibiting 64–67% higher firmness than the control. This improvement was closely associated with a pronounced suppression of cell wall-degrading enzymes—polygalacturonase, pectin methylesterase, and cellulase—by 51–56% under T_5. Biochemical profiling demonstrated significant elevation in total soluble solids (TSS), titratable acidity (TA), and ascorbic acid content, accompanied by a 34–36% reduction in respiration rate under T_5, indicating delayed senescence and sustained metabolic balance.Furthermore, the combined treatments substantially enriched the phytochemical composition, with total phenolics, flavonoids, and anthocyanins increasing by 50–52%, 45–47%, and 42–43%, respectively, under T_5 compared with the control. These enhancements were paralleled by improved oxidative stress tolerance, reflected in a 47–48% reduction in malondialdehyde (MDA) content and a 40–45% upregulation in key antioxidant enzymes (SOD, CAT, APX, and POD). Principal component analysis (PCA) distinctly separated quality-related parameters (firmness, TSS, antioxidants, and phenolics) from senescence-linked traits (PG, PME, MDA, and respiration), while the correlation matrix confirmed strong positive associations among firmness, sugars, phenolics, and antioxidant enzymes. Collectively, the findings demonstrate that the integration of preharvest SA + MH with postharvest 1-MCP constitutes an effective and reproducible strategy for mitigating oxidative damage, delaying softening, and enhancing the biochemical and phytochemical quality of strawberry fruits during storage. This integrated pre- and postharvest approach offers a sustainable means to extend shelf life, preserve nutritional integrity, and improve marketable fruit quality under commercial cold storage conditions.

Keywords: Salicylic acid, Maleic hydrazide, 1-Methylcyclopropene, Antioxidant enzymes, Strawberry fruit quality

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