

## Review and Progress

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# Sweetness and Acidity Traits in Strawberry (*Fragaria* × *ananassa*): Research Progress and Perspectives

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**Abstract** Strawberry flavor quality is a pivotal factor determining its commercial value and consumer acceptance; among its attributes, sweetness and acidity serve as core sensory indicators that directly influence fruit palatability and market competitiveness. This paper systematically reviews the research progress regarding sweetness and acidity traits in strawberries. Drawing upon both sensory evaluation and physicochemical foundations, it analyzes the compositional characteristics of sugars and organic acids, as well as the dynamic patterns of their accumulation. Furthermore, the paper elucidates the metabolic pathways for carbohydrates and organic acids—including the regulatory mechanisms of key enzymes—and summarizes the genetic basis and molecular regulatory networks underlying these traits. Building upon this foundation, the study explores the impact of environmental factors and cultivation practices on sugar and acid accumulation, as well as the application of both traditional and molecular-assisted breeding techniques in quality improvement. Concurrently, through case studies of exemplary high-quality varieties, the paper reveals practical strategies and demonstrated outcomes for the improvement of sweetness and acidity traits. Finally, integrating the advancements in multi-omics technologies and precision breeding, the paper outlines future directions for research into strawberry flavor quality. This review aims to provide a theoretical basis and technical reference for the selection and breeding of high-quality, high-sweetness, and low-acidity strawberry varieties, as well as for the overall upgrading of the strawberry industry.

**Keywords** Strawberry; Sweetness; Acidity; Sugar-acid metabolism; Molecular breeding

## 1 Introduction

Strawberry (*Fragaria* × *ananassa*) is a globally important horticultural crop valued for its bright color, nutritional benefits, and distinctive flavor profile, making it a key component of fresh fruit markets and processed products worldwide (Barbey et al., 2021). However, decades of breeding focused on yield, firmness, appearance, and disease resistance have often led to a decline in perceived flavor quality, with many modern cultivars regarded as bland compared with wild relatives or older varieties (Porter et al., 2023). Recent sensory and multi-omics studies have highlighted flavor—particularly the balance of sweetness and acidity combined with characteristic aroma—as a central determinant of consumer satisfaction and a renewed priority for breeding programs. Within overall flavor, sweetness and acidity are core taste traits that directly influence both hedonic response and repeat purchase decisions.

Strawberry flavor perception arises from the integration of taste (sugars and organic acids), aroma (volatile organic compounds), and texture, with sweetness and acids providing the fundamental taste framework on which volatiles build complexity (Wang et al., 2025). Large sensory-chemical studies show that consumer liking is most strongly associated with sweetness intensity and strawberry flavor intensity, while sourness contributes less directly to overall preference yet still shapes the perceived balance of taste (Liu et al., 2023; Mezghina and Tikhonova, 2025). Biochemically, nonvolatile sugars such as glucose, fructose, and sucrose and organic acids such as citric and malic define the sweetness-acidity profile, and their ratio is often a better indicator of perceived flavor than absolute concentrations alone. In this context, dissecting the genetic, metabolic, and environmental determinants of sweetness and acidity has become essential for guiding both breeding and cultivation practices.

Consumer studies consistently indicate that strawberries are purchased and consumed primarily for their pleasant aroma and sweet taste, and that high sweetness and balanced acidity are key drivers of preference across diverse markets (Sturzeanu et al., 2025). Psychophysical and panel work has shown that overall liking is closely tied to