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Elucidation of the Molecular Mechanisms in the "Concentration Effect" of the Salt-induced Sweetening in Tomato Fruits

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Summary

One method for producing high-sugar tomatoes involves inducing osmotic stress with salt. Under salt stress, the fruit becomes smaller, causing photosynthetic products to concentrate and increase the sugar content (the concentration theory). While this reduction in fruit size has been attributed to a decrease in turgor pressure due to osmotic pressure, recent studies have shown that in plants under water stress, such as drought, active growth inhibition at the genetic level occurs before turgor pressure drops. Therefore, this study aims to investigate whether active growth inhibition at the genetic level also occurs during the process of fruit size reduction under salt stress in tomatoes, and to elucidate the molecular mechanism behind the concentration effect induced by salt stress.

Using a hydroponic system, tomatoes were cultivated in a standard nutrient solution and in a nutrient solution with added salt. The growth, weight, and sugar content of the fruit were analyzed. Additionally, tissue sections were prepared to compare cell sizes. Furthermore, quantitative RT-PCR and transcriptome analysis were conducted around the period when the fruit size increased, to analyze changes in gene expression.

The results showed that the difference in fruit size due to the presence or absence of salt stress became significant around 10 days after pollination. Observation of tissue sections confirmed that the reduction in fruit size under salt stress was accompanied by a decrease in cell size. Quantitative RT-PCR and transcriptome analysis of gene expression at 5 and 15 days after pollination revealed that the expression of genes related to cell elongation decreased under salt stress. Additionally, the expression of genes involved in the synthesis and response of several plant hormones, such as auxins and gibberellins, was altered by salt stress. While the previously noted increase in the expression of starch synthesis genes was observed, it was also revealed that the expression of photosynthesis-related genes generally increased.

The decrease in the expression of genes promoting cell elongation due to salt stress suggests that fruit size reduction is controlled at the genetic level. Furthermore, changes in the expression of genes related to the synthesis and response of multiple plant hormones indicate that salt stress has a broad impact on fruit physiology. On the other hand, the increase in the expression of photosynthesis-related genes in the early stages of fruit development under salt stress suggests the possibility that the activation of photosynthesis within the fruit contributes to sugar accumulation, presenting a potential mechanism other than the concentration effect for the increase in fruit sugar content under salt stress.