Cell expansion-division under resource sharing: a novel framework for understanding and predicting fruit growth dynamics

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Résumé

Understanding the complex dynamics of fruit growth is crucial for optimising agricultural practices and enhancing food production. Observation difficulties pose a challenge to developing of models capable of providing a mechanistic description of the cellular processes at play, while reproducing the macroscopic observables of interest. This study presents a novel mathematical framework that integrates mass-dependent expansion, cell division, and resource sharing mechanisms to model fruit growth dynamics. The framework is applied to empirical data on tomato fruit growth, demonstrating its ability to accurately reproduce the temporal patterns of total cell number and fruit mass, as well as predict cell mass distributions at harvest. The framework enables the separation of the effects of genotypic and environmental factors on the mechanistic parameters related to the biological processes. This sheds light on the possible relationship between genetic traits, growth conditions, and fruit quality traits. Additionally, our framework provides insights into the possible mechanisms of nutrient content optimisation and offers valuable implications for improving agricultural practices. Our study presents a unified approach to modelling fruit growth dynamics, which has potential implications for understanding other multicellular systems characterised by resource sharing.

Mots-Clés: expansion, division dynamics, mathematical modelling, fruit growth, fruit quality, Population Balance Equation

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