Application of multicomponent Time Temperature Integrators for optimization of the monitoring accuracy and reliability of the food chill chain

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Temperature conditions in the chill distribution often deviate from the recommended ones, making continuous monitoring of foods crucial for their quality at consumption. TTI are useful tools for an effective chill chain management. However, for a reliable TTI application the temperature dependence of the TTI response and the food quality loss rates (expressed by the respective activation energies, E_A) should be identical. When this stringent prerequisite is not fully met, the error in the evaluation of the integrated impact of time-temperature history may lead to substantial error in quality estimation.

The objective of this work is to optimize chill chain monitoring and quality assessment. The potential to use multicomponent systems with different kinetic characteristics, instead of single tags, is studied and the error reduction accomplished is calculated.

Two-component TTIs, consisting of separate, independently functioning tags were used. A systematic kinetic study of TTI response was realized (E_A = 70 - 150 kJ/mol), and the kinetic model was validated under nonisothermal conditions. Reproducibility of the response of each TTI was assessed based on experiments of a large number of TTI units. These systems were used on food products with spoilage rates of different E_A, simulating alternative distribution scenarios.

The results showed that a correction factor could be estimated, based on the response and the kinetic features of the two TTIs. When a multiple system is used instead of a single tag, the maximum error in effective temperature (T_{eff}) estimation can be reduced from ±2°C to ±0.05°C, minimizing the error in food quality estimation from ±19 to ±1%.

The use of a multiple system offers a sound alternative to the single TTI with E_A similar to the food's. Minimization of the error in the prediction of the T_{eff} of the food is achieved based on the developed and validated correction procedure.